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ABBREVIATIONS

AAFRD	**Alberta agriculture, forestry and rural economic development (Canada)**
AR	**Autoregressive model**
B	**Boron**
BO	**Blackberry oil**
C	**Carbon**
CA	**Carbonic anhydrase**
Ca	**Calcium**
Cu	**Copper**
CEC	**Cation exchange capacity**
CW	**Constructed wetland**
DoA	**Description of actions**
ELT	**Ecolodge of Tinos**
EMA	**European medical agency**
ESCWA	**United Nations economic and social commission for western Asia**
FAO	**Food and agriculture organization**
FAOSTAT	**Food and agriculture organization corporate statistical database**
FC	**Water capacity**
Fe	**Iron**
FFA	**Free fatty acid content**
GDP	**Gross domestic product**
GH	**Greenhouse**
K	**Potassium**
LDPE	**Low density polyethylene**
LS	**Loamy sand**
Mg	**Magnesium**
Mn	**Manganese**
N	**Nitrogen**
P	**Phosphorus**
PFAF	**Plants for a future**
PGI	**Protected geographical indication**
PV	**Peroxide values**
PWP	**Permanent wilting point**
RDI	**Regulated deficit irrigation**
SEG	**Seawater greenhouse**
SP	**Saturation water**
UASB	**Upflow anaerobic sludge blanket (biogas system)**
UNECE	**United Nations economic commission for Europe**
USDA	**United States department of agriculture**
WWTP	**Wastewater treatment plant**
Zn	**Zinc**

EXECUTIVE SUMMARY

The HYDROUSA project aims at maximizing the benefits of different water treatment systems to reuse water from various non-conventional sources of water. HYDROUSA will implement different agricultural systems based on the nature, interests and water system at each island. The water system is referred in HYDROUSA project (and in this deliverable) as "HYDRO". HYDROUSA implements 6 demonstration sites located in three Greek islands; HYDRO 1 and 2, are located in the island of Lesvos, HYDRO 3 and 4 are located in the island of Mykonos, and HYDRO 5 and 6 are located in the island of Tinos.

Deliverable D4.2 "Design of Agricultural Sites" included a full description for each HYDRO system (1-6) along with the climate data, soil works, plant selection, design of the site and the irrigation system applied to the specific site. This report (D4.3 "Catalogue of selected plants, description, availability and product development options") is an inclusive and detailed description of all plants selected for each agricultural system applied and soil analysis that would allow each site manager to understand all requirements and prospects, and follow a definite plan for implementation and monitoring.

Our methodology consisted of the following steps: (a) create a stakeholder mapping i.e., identify interest groups, communities, organizations, university departments to be invited to the public workshop, (b) research on ethnobotanical studies for the island.

This report creates a catalogue of suitable plants used in the past on the island and how the agricultural production has been related to the culture. (d) Create a questionnaire for Interviews related to agriculture and its practices (e) Identify persons with this old plant and farming knowledge and interview them, (f) organize the community-involving workshops with this knowledge and the proposed plants and technologies the consortium suggests. (g) This co-creation workshop defines the interest of the community for community farming or community supported agriculture.

An extensive plant list for each agricultural site in the three islands has been prepared based on the outputs of the co-creation workshops and plant expert's discussion within the project consortium. In general, a total of 60 plant species were selected for the plantation of the agricultural sites (21 species of edible trees, 7 species of non-edible trees, 14 species of edible shrubs, 4 species of non-edible shrubs and 14 species of dry-soil plants).

In Lesvos Island, an agroforestry agricultural system will be adopted and irrigated from the water system of HYDRO 2. The quality and quantity of treated water produced from HYDRO 1 system is nutrient-rich, sufficient to cultivate more than 1.0 ha land-area. Therefore, an agroforestry system, where many species and types are cultivated, seems to be the most efficient system to create a diverse of crops to citizen and a business model for the island and for replication purposes. In general, an agroforestry conserves biodiversity in the following ways: (1) provision of habitat for species that can tolerate a certain level of disturbance; (2) helping to preserve the germplasm of sensitive species; (3) reduction of the conversion rates of natural habitat by providing a more productive, sustainable alternative to traditional agricultural systems that may involve clearing natural habitats; (4) provision of connectivity by creating corridors between habitat remnants, which may support the integrity of these remnants and the conservation of area-sensitive floral and faunal species; and (5) supporting biological diversity conservation, by providing other ecosystem services such as erosion control and water recharge, thereby preventing the degradation and loss of surrounding habitat.

In Mykonos Island, two HYDRO systems are implemented; HYDRO 3 and 4. These two systems are depending on collection of rainwater; and through slow-sand filters and aquifers the water quality is improved to be used for irrigation. Mykonos Island is in a dry weather most of the summertime and short rain season during winter. In addition, Mykonos Island has a high touristic dimension and, therefore, the type of crops to be cultivated (depending on the water quantity and quality of HYDRO 3 and 4) should match these characteristics. Oregano and lavender are two dry soil crops cultivated for the use of their "high-value" essential oils. Oregano has been used for centuries for a variety of its health improving properties. It contains multiple antibacterial and antimicrobial properties. It has been used to relieve coughs, reduce body odour, soothe digestive muscles, and lower blood pressure. Oregano is a strong antioxidant, with high levels of beneficial acids and flavonoids. Lavender is a perennial plant that can live up to 20 years if the conditions are optimum. It produces purple flowers, which contain high levels of essential oil. Mediterranean countries (Italy, France, and Spain) have long tradition in growing lavender. Nowadays, countries such as USA, Canada, Japan, Australia, and New Zealand are also considerable commercial lavender producers. The essential oil of lavender is recognized globally as a respected commodity. It has several medicinal and other uses. It also has remarkable antiseptic and antimicrobial action.

Tinos island is a point of attraction to tourists and the HYDROUSA project aims at providing added values to the island. Two HYDRO systems will be implemented in Tinos: HYDRO 5 and HYDRO 6.

HYDRO 5 is an innovative technology to desalinate seawater and brine to produce fresh water. Exotic plants were specially selected for production in this demo site. These plants include; pineapples, papaya, ginger, ginseng, passion fruit, turmeric and bananas. Tinos island has no history of producing these plants; thus, it will be a high value-added to the island, when these plants grow, and their fruits will be branded as Tinos exotic fruits.

HYDRO 6 water system is located at Tinos Ecolodge (ELT) and it is a mixture of different systems; including rainwater harvesting, reclaimed wastewater and surface water The Tinos Ecolodge is one of the main points of attraction in Tinos Island. It brings yearly hundreds of tourists, who would like to spend time embracing nature and living the experience of living in a nature-based society. The business model that the Tinos Ecolodge is adopting is based on circular loops of water, energy and now it should be cropping as well. Tourists who visit the Ecolodge are interested to learn the meaning of growing plants and taking care of them and how these plants could grow with reused water and in soil that have been treated with a home-made compost. Therefore, a variety of plants are foreseen to be cultivated in this demo site. These plants include edible plants, plants for production of essential oils, functional plants, etc. The advantage of having these different water systems is to plant these varieties of plants to serve different purposes. Harvested rainwater, reclaimed wastewater and collected surface water will be used to irrigate edible plants, herbal and medical plants.

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1. INTRODUCTION

As describes in the Description of Actions (DoA), HYDROUSA provides among others innovative, regenerative and circular solutions for (a) nutrient management, boosting the agricultural and energy profile; and (b) local economies, based on circular value chains. The services provided lead to a win-win-win situation for the economy, environment and community within the water-energy-food-employment nexus.

The HYDROUSA project intends to maximize the benefits of different water treatment systems in closed loops to reuse water originating from different non-conventional water sources. This is demonstrated in six different demonstration sites, which are referred to as HYDRO1-6.

HYDROUSA has a strong agronomic dimension since in all cases agricultural reuse is at least one of the intended uses. Within HYDROUSA we will have different agricultural applications corresponding to the demonstration sites, cultivating different types of plants that are chosen based on the environmental conditions of the demo site and also on their potential to provide high market value to the island, where the demo site is located.

For that purpose, a structured plan was set to define the factors that determine the agricultural conditions and designs, and these are:

- Community engagement plan was prepared and described in D4.1. Local communities have contributed with their knowledge and ambitions on what to achieve from these different innovative models. These models are directed towards benefitting the island and the people as the water is economically used to irrigate plants with high market value
- Technical tours to visit and study each site in terms of location, weather conditions, accessibility to the public, protection, etc.
- Soil sampling and analysis in each site
- Selection of the most suitable plants for each site and description of each plant,
- Irrigation system for each site, and
- Design of the site with a plantation plan.

This report is a comprehensive description of all plant species that were selected for cultivation in the 3 islands of the HYDROUSA project; demo site 2 is located in Lesvos Island, demo sites 3 and 4 are located in Mykonos Island, and demo sites 5 and 6 are located in Tinos Island.

Sensors will be installed for the monitoring and assessment of the soil moisture in all sites. Other parameters will also be determined that affect the irrigation plan; these parameters include water distribution in the water tanks and weather conditions. The aim is to optimize water use for the production of crops. Furthermore, solenoid valves will be installed to ensure the automation of the process of irrigation. Finally, the aforementioned data will be collected and processed further in order to enhance and regulate the application of water.

In all demo sites, complete soil structure analysis was performed to determine nutrient and water needs of the soil and plants as well as to determine the type of works and treatment the soil should receive prior to cultivation. Climate data was also collected for all demonstration sites. Determination of plants would depend on all soil structure and meteorological data collected.

2. SITE INFORMATION

2.1 The agroforestry system (HYDRO 2)

The output of the local community was that fruit trees will be used as wind protectors and shade providers, shrubs as superfood providers, and several local varieties of vegetable crops and aromatic plants as added value products. High value plants will be combined with beneficial organisms attracting other species to create resilience with diversity (see Figure 2.1).

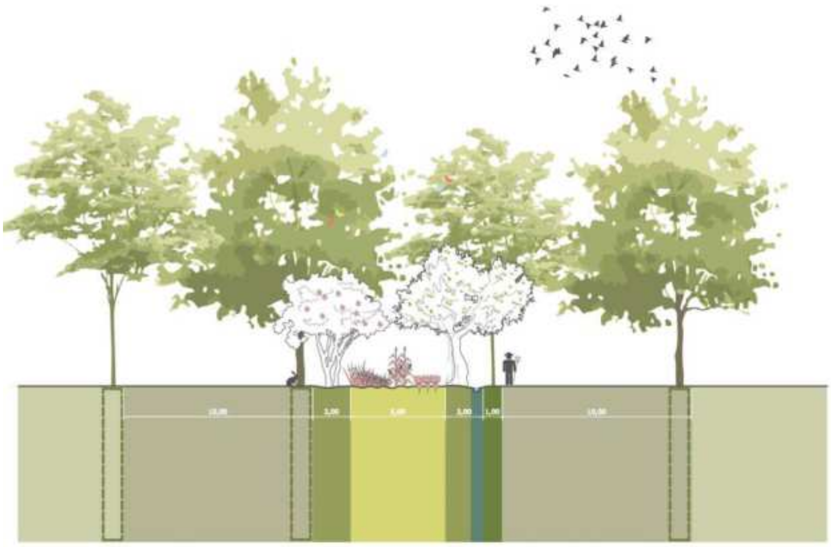

Figure 2.1 A demonstration of the orientation of trees, shrubs and other crops within an agroforestry system

2.1.1 Community engagement at Antissa

The 1st co-creation workshop in Antissa took place on Saturday 8th of December 2019 in the framework of T4.1 Community engagement and citizen science to adapt the design to regional circumstances, T5.2 User requirements and specifications definition for monitoring and controlling, and T9.6 User requirements, co-creation and training activities. The workshop was held in Greek. First step in the design was to list the kind of participants, which shall be invited to the workshop (stakeholder mapping), the second step was to match the content of the workshop with the activities of the three tasks T4.1, T5.2 and T9.6.

First, the stakeholder mapping consists of "personas type" and "project requirements". For examples personas type are such as school teachers, local farmers, local public servants, etc. The matching of these personas to project's requirements is based on science communication activities, sharing local agricultural knowledge, networking and so on (See Table 2.1). A stakeholder list with personas and associations (e.g., women agricultural associations, community supported agriculture initiatives, farmers) related to the agricultural activities at Antissa or in Lesvos is included in this report (See Table 5.2 HYDRO2).

The workshop's format involved two methodologies: a. the appreciative inquiry and b. the world café. In the beginning, the participants introduced themselves and answered to two questions: a. What do you enjoy the most in the area? and b. What exists in Antissa/you are proud of? Then, they worked in groups with following three questions and presented the outcomes in the larger groups:

What are the well adopted agricultural plans in the region-nowadays and past?

What are the irrigation methods and what the challenges, -nowadays and past?

How do they imagine the agroforestry system?

In total, the attendees represented the different persona types such as farmers, students, elderly, teachers, local authorities). This workshop gave inputs on designing the agroforestry system, knowledge on regional plants, old water catchment techniques and related contacts. Last but not least, this workshop served as the first step towards community building; to embrace the project and explore the opportunities of local development on different aspects.

Table 2.1 Persona type and project's requirements at Antissa

Persona Type	Project's requirement
Young residents from Antissa	support with work in the field
impactful position in local Authorities	connect us with people and provide info
Older residents from Antissa	narrate traditions
school teacher	educate children on the program and help with future summer camps
university professor	provide with info and educate students on the program
local opinion leader	connect us with other people
Farmer	support with work in the field and provide know how
Women's associations	
expert on local plants	consulting on plant selection
local partner	provide network of contacts, credibility and info
local public servant	logistics support, local media contact
local business owner	
Journalists	disseminate project

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Figure 2.2 Co-creation HYDROUSA workshop in Antissa

Figure 2.2 shows the local community in action during the workshop at Municipality's cultural center. The participants worked in groups to share practices and co design the agroforestry.

Inputs from the workshop are described below (see also Figure 2.3);

What are the well adapted agricultural plans in the region-nowadays and past?

In the past, tobacco was cultivated because it was subsidized until 1970s. Wheat, barley, mulberries, clover and others were also cultivated. Nowadays, olives shrubs and clover are mainly planted.

What are the irrigation methods and what are the challenges, -nowadays and past?

In the past, water from the river was used for irrigation. Fifty years ago, two water sources were at Antissa. Water from these sources flew to the long path "avlaki" or "tsimentavlakas" (cement path) and reached the fields for irrigation. "Hydronomeas" was a type of job for the one who was responsible to adjust the water distribution. This system is applied nowadays at Filia on Lesvos island. "Gioles", also called "havutzes", tanks for rainfall storage were also applied. Nowadays, there is a well or borehole water in each field, which irrigates through micro-sprinklers or drip irrigation with plastic piles. In the past, animals such as cows or asses, mules used to plough the land, nowadays, motor cultivators cover these needs.

How do they imagine the agroforestry system?

Many inputs regarding the dreamed "agroforestry" were shared including large variety of plants with focus on the local ones surrounded from animals. Infrastructures to shape a friendly environment for the local community were also described such as a small lake, barbeque, wooden tables and chairs, electricity supply and lights, eco or compost toilets, potable water from a tap, emergency pharmacy box, plant nursery, beehives, food dehydrator, and a seed library.

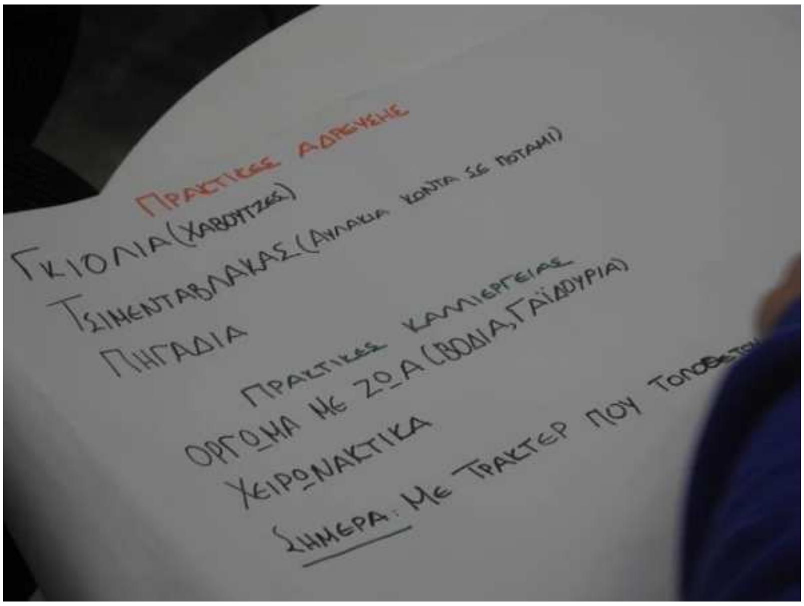

Figure 2.3 Irrigation practices (list) in the past years - Co-creation HYDROUSA workshop in Antissa

Agroforestry is a land management practice that bridges the gap between agriculture and forestry by creating integrated systems, where trees and shrubs are deliberately planted among agricultural crops and/or livestock in a dynamic, ecological and natural system (Brown et al., 1995). This system provides a variety of environmental, economic and social benefits for land users, when compared to conventional agriculture (FAO, 2014).

HYDRO2 is an agricultural land which is adjacent to HYDRO1 and will be upgraded to an agroforestry system with a much larger diversity of trees, crops and shrubs. HYDRO2 is in total 1 ha (two fields of 0.7 ha & 0.3 ha) of agroforestry on Lesvos Island, irrigated with nutrient rich reclaimed water after treatment in UASB-CW system. In HYDRO2 part of the irrigation system shall consist of masonry channels from the local area, which will be prepared with the delicate knowledge of the old profession of stone masonry. (See Figure 2.1 & 2.4 HYDRO2 Demo site description).

Connections with local farmer associations and gardeners have already been established (See Stakeholder list, Table 5.2) supporting HYDROUSA with the organization of desired plants.

In the agroforestry system, HYDRO2, the concept will integrate biodiverse and resilient agroforestry ecosystems and selection of plants, which are well adapted to dry and windy conditions and have high market values. The agroforestry system will be divided in 3 main groups: (1) tall forestry like trees (e.g., laurel tree, cork tree, sweet chestnut), (2) medium-canopy small trees/bushes (e.g. goji berries, pomegranate, sea buckthorn and olive shrub), herbs (e.g. lavender, sage, oregano, thyme, mint) and (3) annual crops. It will produce superfoods, high added value herbs, local fruits, and timber. After the growth periods, the residual biomass will be shredded and used for co-composting in the closed vessel system of HYDRO1. The produced compost will be used again in the agricultural systems.

The plant setup will be co-creatively elaborated with the public for a definition of business cases forming resilient ecosystems. The catalogue of selected plants, description, and availability and product development options is implemented within the activities of HYDROUSA.

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This report gives insights to create the comprehensive catalogue of all the plants & crops which will be grown on the sites. This report is developed based a) on literature review on ethnobotanical studies and other related publications linked to Lesvos b) and HYDROUSA's pilot in Antissa (See Table 5.1 Literature review on agricultural and ethnobotanical studies in Lesvos, and with inputs of the local community through the participatory workshop (See Workshop with the community in Antissa), and c) interviews with locals and stakeholders (See Inputs from interviews). Taking into account the soil analysis that was conducted and other criteria, such as the prospects of the selected plants in the market, the final decision on plant selection was made.

2.1.2 Soil analysis

The physicochemical analysis of the soil was performed to determine the soil properties in terms of composition and chemical characteristics as well as the pH and electrical conductivity. Based on the results (see Table 2.2), the two areas (0.7 ha and 0.3 ha) presented more or less similar properties. One sampling point from each cultivation plot (total 5 plots) was determined and soil samples were taken from each plot at 3 depths, 30 cm, 60 cm and 100 cm (see section 6 for detailed report on soil analysis).

Table 2.2 Soil analysis results of Agroforestry cultivation land areas

Particle size:		Moderately heavy soil, likely to cause drainage problems Check if the ground is deep enough, there is no impermeable horizon, and if the underground water level is deep enough.
pH :		pH is suitable for cultivation of Prunus, Olive, Pomegranate trees as well as annual crops and perennials
		Normal pH for culture. Cation exchange capacity produces close to 100% of nutrients.
Electrical Conductivity:	**Very low**	Possible appearance of deficiencies. Poor soil with low microbial activity
Total Calcium Carbonate:	**Low**	Lime recommended
Active Active Calcium Carbonate:		There are no problems with cultivation
Organic matter:	**Very Low**	It is recommended to add, 20 – 25 t/ha of well decomposition animal manure or 1,700 – 2,000 kg per ha of compost, in winter or at least one month before sowing or planting. Reduce the nitrogen dose by 1.5 - 2 units per ton of manure added
C.E.C. (Cation Exchange Capacity):		Normal soil for cultivation

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C/N ratio:	Intense biological activity, favorable conditions of decomposition of plant debris and release of inorganic nutrients.

The soil pH ranges from 6.7 to 8.2. These pH levels show mobilisation of nutrients and good potential of bacterial growth so; the soil fertility would be good. Soil testing showed that there is a high sand content compared to the other two soil structure components, but this information should be treated with caution as it is the average of only 5 samples in a 1 ha area. These characteristics indicate that the soil has a good water holding property to hold the irrigation water and thus, it would not dry fast during summer time. Only the soil organic matter of the topsoil was very low ranging between 0.2 and 1%, which are usually classified as dessert soils.

2.1.3 Irrigation

The agroforestry demo site is divided into three main fields. Two irrigations systems will be used in the agroforestry site. The first system is drip irrigation system (see Figure 2.4 and Table 2.3). In field 1, the plot (lines) 1-6, 15 and 16 is irrigated using drip irrigation system. Trees are at distances of 10 x 10 m, while, Methna spicata plants are cultivated in distances of 0.7 x 0.7 m (vertically) and 0.3 x 0.3 m horizontally. The dripping hoses are aligned horizontally with plants.

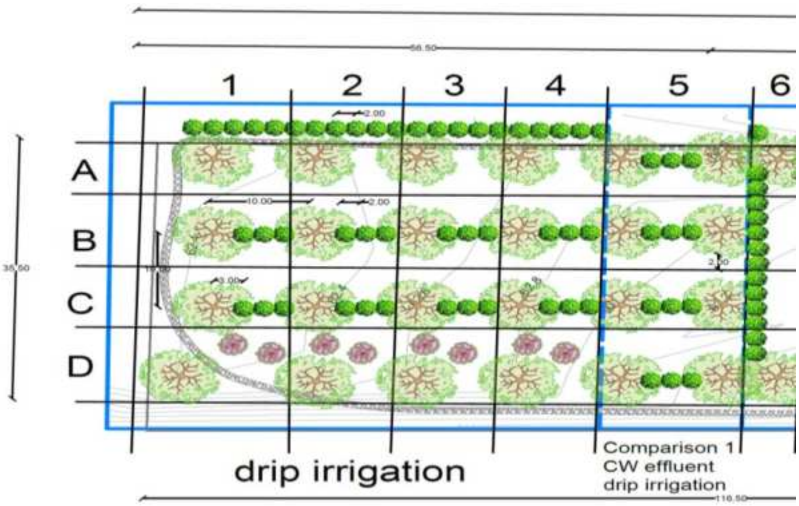

Figure 2.4 Plot 1 in Field 1 - irrigation with nutrient-rich treated wastewater from CWs

Table 2.3 Field 1 - drip irrigation lines distribution and distances in-line with plants and plots

			Drip Irrigation of treated wastewater																			
5							1												COMPARISON 1			
	m	m	1				2				3				4				5			
bush hedge	35	1	5 x Lycium barbarum (goji berry)				5 x Hippophae rhamnoides				5 x Lycium barbarum (goji berry)				5 x Hippophae rhamnoides							
	34	1																				
trees	33	1	Quercus ithaburensis		Punica granatum (Pomegrana		Corylus maxima		Punica granatum (Pomegranate		Quercus ithaburensis		Punica granatum (Pomegranate		Corylus maxima		Punica granatum (Pomegranate)		olea europaea	Hippophae rhamnoides	Lycium barbarum	Lycium barbarum
	32	1.5																				
	31	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	30	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	29	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	28	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	28	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	27	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	26	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	26	1.5																				
trees	24	1	Ficus carica	Hippophae rhamnoides	Lycium barbarum	Myrtus communis	Prunus dulcis	Hippophae rhamnoides	Lycium barbarum	Myrtus communis	Ficus carica	Hippophae rhamnoides	Lycium barbarum	Myrtus communis	Prunus dulcis	Hippophae rhamnoides	Lycium barbarum	Myrtus communis	olea europaea	Hippophae rhamnoides	Lycium barbarum	Lycium barbarum
	23	1.5																				
	22	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	21	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	20	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	20	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	19	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	18	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	17	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	17	1.5																				
trees	15	1	Ficus carica	Hippophae rhamnoides	Lycium barbarum	Myrtus communis	Prunus dulcis	Hippophae rhamnoides	Lycium barbarum	Myrtus communis	Ficus carica	Hippophae rhamnoides	Lycium barbarum	Myrtus communis	Prunus dulcis	Hippophae rhamnoides	Lycium barbarum	Myrtus communis	olea europaea	Hippophae rhamnoides	Lycium barbarum	Lycium barbarum
	14	1.5																				
	13	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	12	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	11	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	11	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	10	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	9	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	9	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	8	1.5																				
trees	6	1	Moringa		Moringa		Moringa		Moringa		Moringa		Moringa		Moringa		Moringa		olea europaea	Hippophae rhamnoides	Lycium barbarum	Lycium barbarum
	5	1.5																				
	4	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	3	0.7	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata	Mentha spicata
	2	1.5																				
trees	1	1	Quercus ithaburensis		Punica granatum (Pomegranate)		Corylus maxima		Punica granatum (Pomegranate)		Corylus maxima		Punica granatum (Pomegranate)		Corylus maxima		Punica granatum (Pomegranate)		olea europaea			
	0	1	1				2				3				4				5			

Plot number 2 in field 1 (from line 7 to 14) will be irrigated with open channels, made of one main stone channel and secondary soil furrows supported by plant wood branches (bioengineering channels) and then peripheral soil furrows (tertiary channels). The water goes from the main stone-channel to the side furrows through automated actuators that open or close based on moisture sensors, which determine the need of plants for irrigation in order to preserve water. To minimize water loss, the field is designed in a way that plants and trees are oriented in the field based on their water needs; to make the most water demanding plants/trees closest to the main stone-channel and least water demanding plants (dry-soil plants) are cultivated at the far end of the field (see Figure 2.5).

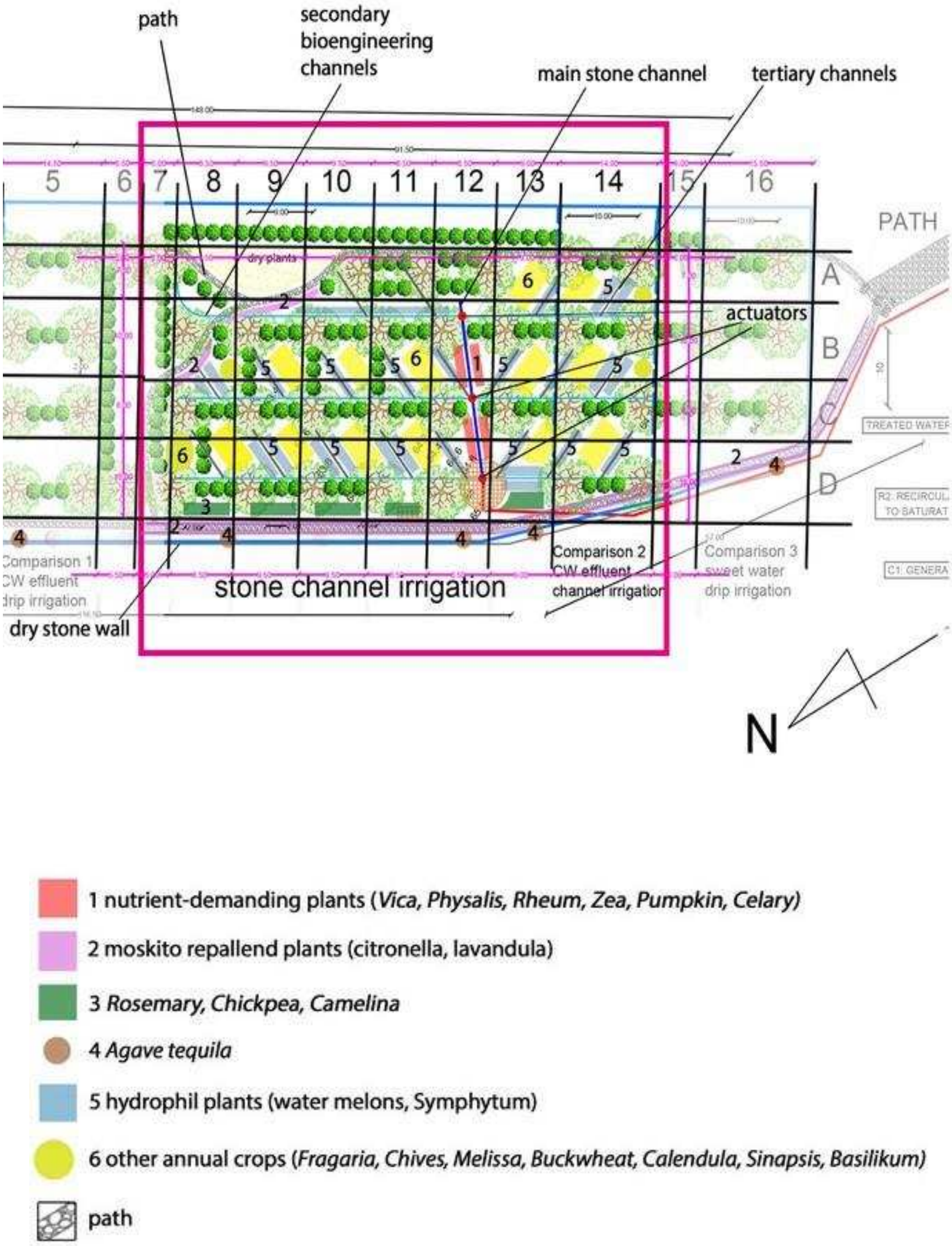

Figure 2.5 Plot number 2 in field 1 - open stone-channel irrigation system and orientation of plants

Methodology for the Determination of the Water Needs of the Agroforestry

Temperature, precipitation and evapotranspiration are some of the main factors that determine the water needs of an arable field. The irrigation of a field with treated wastewater should consider not only the water requirements of the crops, but also their nitrogen requirements, particularly in the case of fertigation where the treated wastewater has significant nitrogen concentrations. In this section a methodology is developed to estimate the long-term daily demand of the irrigated agroforestry fields 1, 2 and 3 that will be irrigated with reclaimed water which contains nitrogen. The water and nutrient needs of the crops are the ones which dictate the amount of water to be fertigated during the dry season (i.e. from April up to September) compared to the available water which is a maximum of 100 m^3/d during the summer period (June to August) and 10 m^3/d the other months.

The HYDRO1 system consists of a treatment scheme that is versatile enough to different levels of treatment and nitrogen removal. In our investigation, we considered three different scenarios of nitrogen content in the reclaimed water used to irrigate the agroforestry field. Through this analysis, the optimum operation scenario can be developed in HYDRO1 that will allow effective recycling of water and nutrients to the crops.

The first step of the methodology is to determine the forecasted precipitation at the area under investigation over the next 10 years, up to 2030. To accomplish this, meteorological data of the region, such as the average daily temperature and the daily precipitation, were collected. The future water demand is forecasted for every irrigation period of the next ten years, which is the period from April up to September. For the remaining months, it is assumed that the water demand is fully covered by rainfalls. The advantage of the methodology that is followed is the time series analysis, which allows us to investigate the mechanism (stochastic process or dynamic system) producing the time series, estimate its features, develop a model to describe it and make predictions of its evolution, that are, the next values of the time series. This allows us to make safe predictions with a small uncertainty for the daily water requirements of the irrigated area, for the better planning and water management.

The methodology which was followed is described in detail below. We need to determine the crop requirements in terms of water and in terms of nitrogen. The annual nitrogen demand and the crop coefficient were collected from the bibliography.

Methodology

Estimation of the future values of the average daily temperature and monthly precipitation

The estimation of the future values of the average daily temperature and monthly precipitation was implemented with the use of autoregressive models, which are models used for timeseries forecasting; these appear to be ideal for hydrological variables. Two different classes of autoregressive models, AR(1) and AR(2), were examined. The model with the best fit to the collected data was selected for the estimation of the future values. In order to utilize the available historical timeseries, stabilization of the timeseries has to be implemented. This is carried out as follows: the average value of the sample is subtracted from the variable value, and subsequently it is divided by its standard deviation (see Equation 1). This results in the “standardized” historical time series as the deterministic part has been removed (see Figures 2.6 and 2.7).

$$X1i,j = (Xi,j - Mj) / SDj \qquad (1)$$

where,

- X1i, j the fixed temperature and rain height value
- Xi, j average daily temperature /monthly rain height

- j the month
- i the year
- Mj the average of the month j
- SDj the standard deviation of the month j

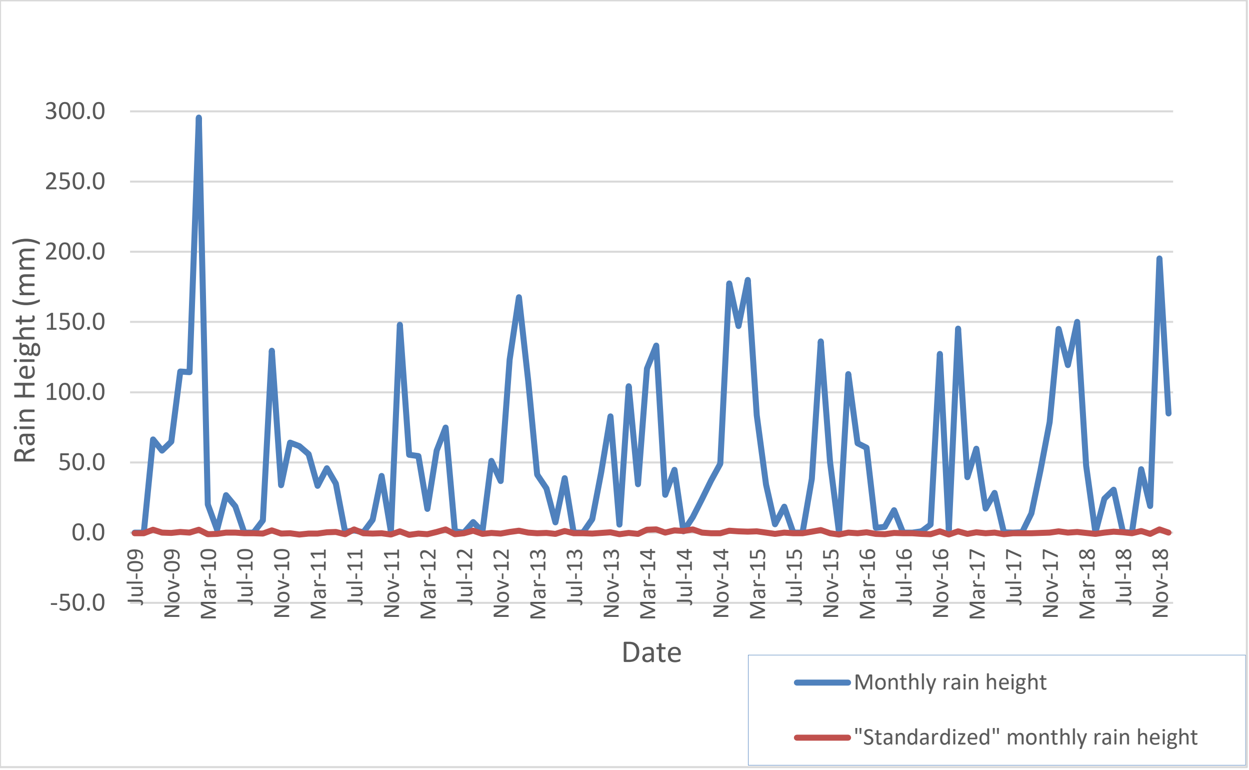

Figure 2.6 Historical and "Standardized" historical rain height time series.

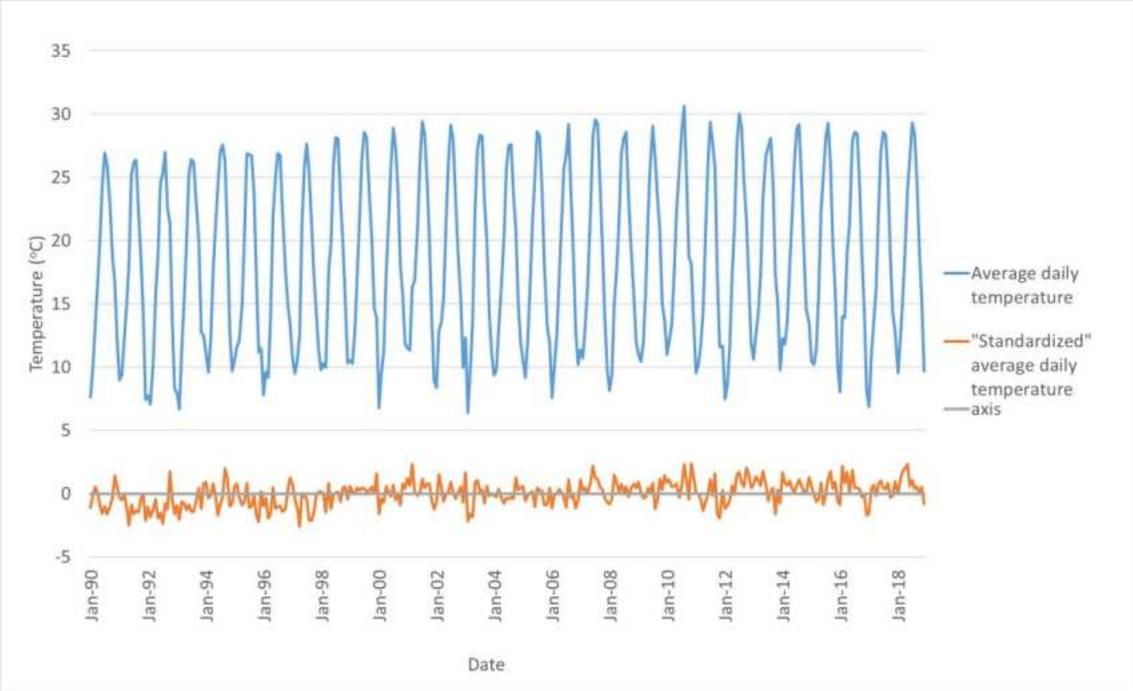

Figure 2.7 Historical and "Standardized" Temperature time series.

The estimation of the model coefficient, the theoretical standard deviation and the remainder for every model and for every timeseries follows next.

The theoretical standard deviation of the series, based on the AR(1) model, is given by the relation in Equations 2 and 3:

$$\sigma z = \sigma q \cdot \sqrt{1 - a_1{}^2} \quad (2)$$

$$\alpha_1 = \rho_1 \quad (3)$$

where,

σq standard deviation of the time series

α1 AR(1) model coefficient

ρ1 first class autocorrelation

The theoretical standard deviation of the series, based on the AR(2) model, is given by the relation in Equations 4 to 6:

$$\sigma\alpha = \sigma q \sqrt{1 - \rho_1\alpha_1 - \rho_2\alpha_2} \quad (4)$$

$$\alpha_1 = \rho_1 - \rho_2 \cdot (1 - \rho_1)1 - \rho_2 \quad (5)$$

$$\alpha_2 = \rho_2 \cdot (1 - \rho_1)1 - \rho_2 \quad (6)$$

where,

σq standard deviation of the timeseries

α1 AR(2) model coefficient first class

α2 AR(2) model coefficient second class

ρ1 first class autocorrelation

ρ2 second class autocorrelation

The choice of the ideal model between AR(1) and AR(2) is based on the Anderson test. Assuming that the chosen model is correct, using the Anderson test, the estimated autocorrelations ρk (εt) of the residuals should not be correlated and distributed in the normal distribution with an average of zero and 1 / N dispersion, i.e. with a standard error: $\alpha = \pm \sqrt{1} / N$, where N is the number of the sample. The deviations from this picture, the self-correlations of the residuals in a model, indicate the degree of inappropriateness. That means, the auto correlogram of the residuals has to be done and two parallel horizontal lines to be drawn on it $\pm \sqrt{1} / N$ from the axis of the time steps. If the autocorrelations for all steps: k = 1,2, ..., 25 do not exceed this limit value, then the model is correct, if it exceeds it, then the model needs changes.

The autocorrelograms obtained with the above data are shown in Figures 2.8 to 2.11.

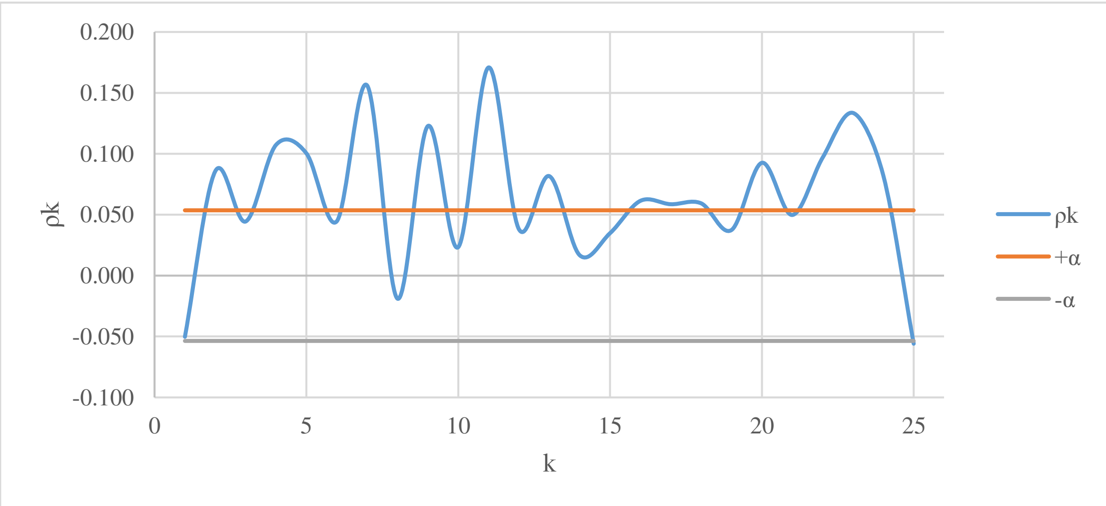

Figure 2.8 AR(1) Temperature Autocorrelogram

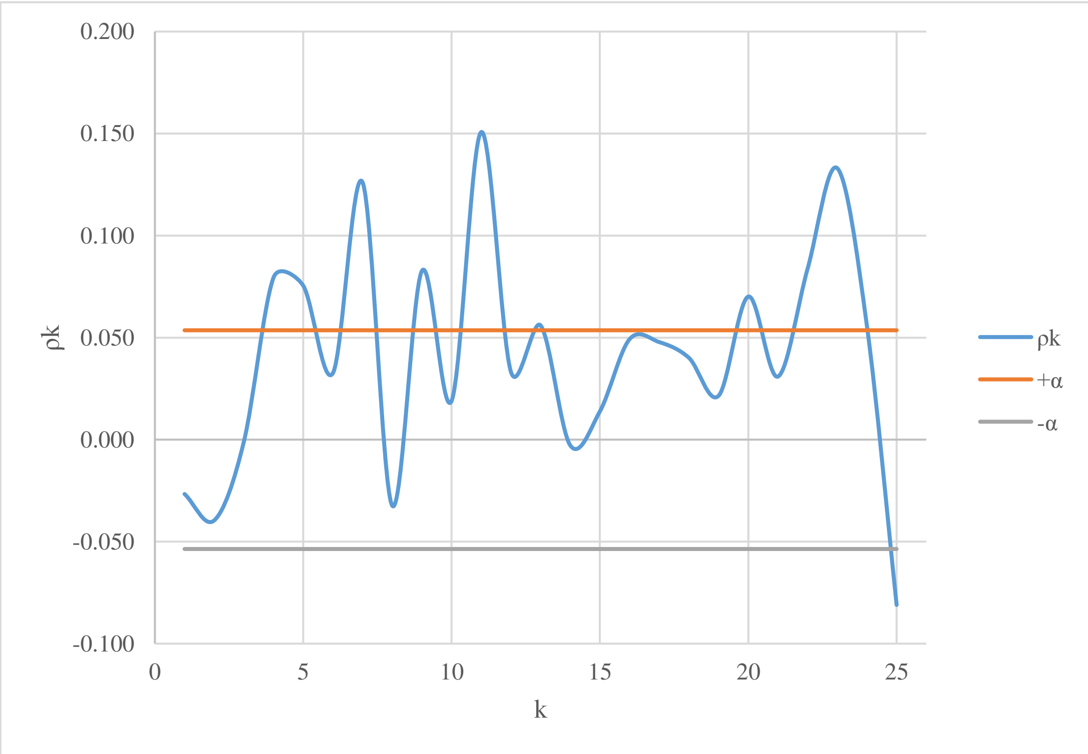

Figure 2.9 AR(2) Temperature Autocorrelogram

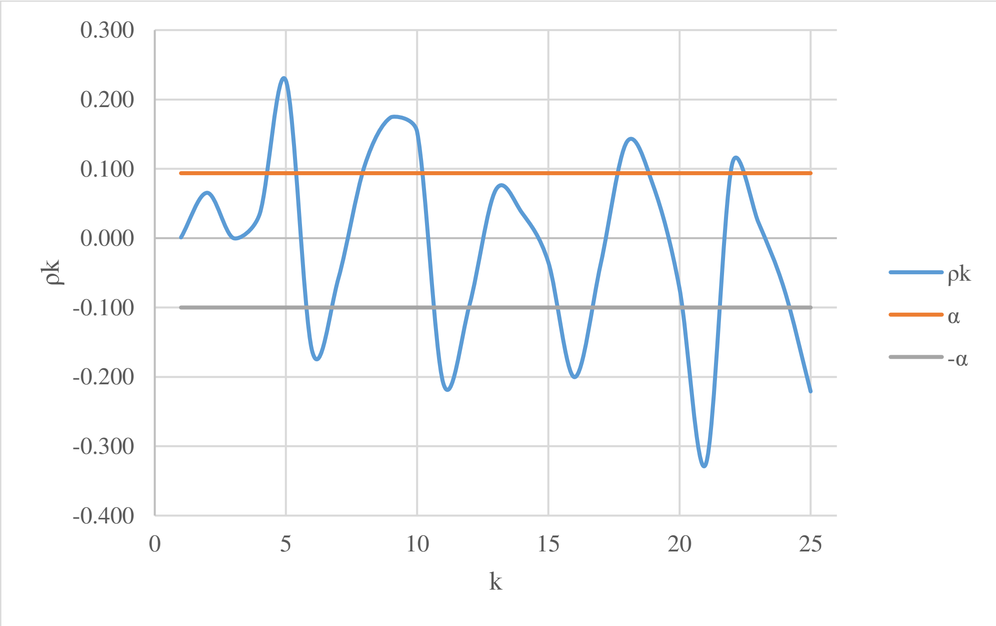

Figure 2.10 AR(1) Rain height Autocorrelogram

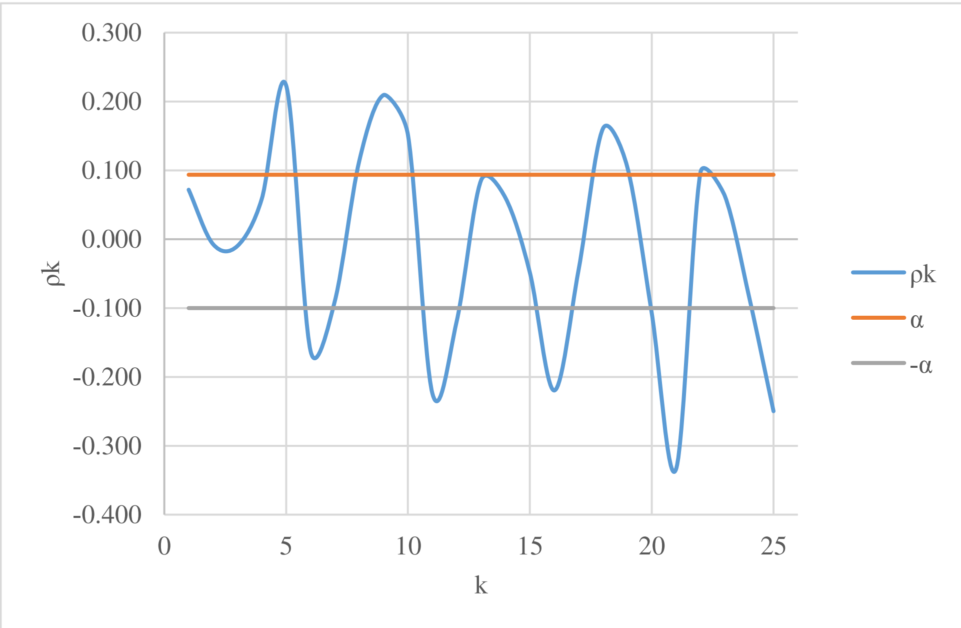

Figure 2.11 AR(2) Rain height Autocorrelogram

As a result of the above, the model with the best adjustment appears to be AR(2) in both cases of the average daily temperature and monthly rain height.
After the selection of the better adjusting model, AR(2), the production of synthetic timeseries of every variable follows next. The estimation of synthetic standardized series values results from Equation 7:
For AR (2),

$$X_i = \sigma\alpha\, NRi + a_1 * X_{i-1} + a_2 * X_{i-2} \qquad (7)$$

where,

σα theoretical AR(2) standard deviation
α_1, α_2 coefficients of AR (2) model
NRi random regular number with mean zero and standard deviation one

Then, to instabilize the synthetic time series, multiply each value by the standard deviation and add the average of the month to which the variable belongs (see Equation 8).

$$X_{i,j} = X1_{i,j} \cdot SD_j + M_j \quad (8)$$

where,

Xi,j the value of the synthetic timeseries
X1i,j the value of the standardized synthetic timeseries
SDj the standard deviation of the month to which the variable belongs
Mj the average of the month to which the variable belongs

The assumption of a total temperature increase of 1% has been made, so the synthetic temperature timeseries are formed as seen in Equation 9:

$$T' = T + 0.01 \cdot T \cdot \frac{m}{N} \qquad (9)$$

where,

T' The final temperature of the synthetic time series
T The initial temperature of the produced synthetic time series
N number corresponding to the length of the time series
M serial number corresponding to each value of the time series from 0 ~ N

For each variable, fifty synthetic timeseries have been produced. Next step is the reduction of the variables to a daily basis, making the necessary assumptions. In temperatures' case, the average daily temperature of each month was considered to be the daily temperature of every day of the month.
The average rainy days of every month of the irrigated period was estimated, utilizing the historical data. Subsequently, for each month of the timeseries, the monthly rain amount of the synthetic time series was randomly distributed over the remaining average rainy days.
The supply will be enriched with nitrogen and phosphorus so the nutritional needs of the crops, or part of them, to be covered. The water content of the above nutrients is not constant, as they will be available three different scenarios of nitrogen and phosphorus contents. The different nitrogen contents are shown below. There will be three different solutions to estimate the demand of the system on a daily basis, one for each possible nitrogen content, so the optimal scenario to be examined, the one that the water and nutrient needs of the crops are both fulfilled as much as possible.

Table 2.4 The three available scenarios of nitrogen content.

N_w		
1st scenario	**2nd scenario**	**3rd scenario**
10 mg/l	20 mg/l	40 mg/l

The following steps are followed for the estimation of the design water demand.

Estimation of evapotranspiration

In order the water needs to be estimated, for each average daily value of the temperature generated by the synthetic time series, the corresponding reference evapotranspiration is calculated using the empirical Blaney-Criddle method corresponding to that temperature. Consequently, a total of 50 average daily reference evaporation timeseries are produced for the next twelve years. The final reference evapotranspiration time series, which is then used to calculate the daily water needs for each month of the next twelve years, is derived from the average of the fifty evapotranspiration timeseries.

The Blaney-Criddle form is depicted in Equations 10 and 11:

$$PET_c = k_c \cdot f \qquad (10)$$

$$f = (32+1.8T_a)/3.94\ P \qquad (11)$$

where,

PETc [mm · d^{-1}] Potential evaporative culture medium
kc Crop coefficient
f [mm · d^{-1}] Climatic factor
T_a [°C] Mean air temperature of the month
P Average daily percentage of total annual duration of day hours as a function of month and latitude

To calculate the net needs, the active rain height is calculated in Equation 12:

$$P_e = 80\%\ P \qquad (12)$$

Pe [mm · d^{-1}] active precipitation
P [mm · d^{-1}] daily rain height

As the area occupied from each crop is a necessary parameter for the estimation of the water demand for both water and nutrient needs, necessary assumptions have been made. In particular, an indicative area of 1.5·1.5 m^2 for trees and shrubs and 0.5·0.5 m^2 for plants was considered.

Estimation of demand for water needs cover

The supply of demand to meet the water needs of each crop is calculated in Equation 13:

$$Q_{w,i} = (PETc - P_e) \cdot A_i \cdot 0.001 \qquad (13)$$

where,

$Q_{w,i}$ [m^3/day] Daily water demand for i crop
k_c Crop coefficient
PET_c [mm/day] Evapotranspiration
P_e [mm/day] Active rain height A_i [m^2] area of cultivation

Estimation of the demand for nutrient needs cover

The estimation of the nitrogen needs of the crops follows next. As there is no much information on the precise distribution of nitrogen demand for plants for each month and therefore each day, but the total necessary quantity in kilograms per hectare per year the following assumption has to be made: The distribution of crop nitrogen demand in the months of the year will be proportional to its evaporation every month. In particular, the daily nitrogen needs will be obtained by multiplying the total amount of nutrients by the fraction of evaporation of the crop of the month to the total evaporation of the year for each crop and then dividing by the days of the month (see Equation 14):

$$U_{N_{DAY}} = \frac{U_N}{30} \cdot \frac{PET_c}{\sum PET_c} \qquad (14)$$

where,

UN_{DAY} [kg/day] the amount of nitrogen demand per crop per day
UN [kg/ha/year] the amount of nitrogen demand per crop per hectare per year
PETc [cm/month] the monthly crop evapotranspiration
ΣPETc [cm/year] annual crop evapotranspiration

In order the nitrogen-based water needs of the crops to be estimated, the methodology of the slow filtration, which is a natural wastewater treatment system, will be utilized. The nitrogen-based water supply, Lwn, in cm / year of the slow filtration system is given by the relation depicted in Equation 15:

$$Lwn = \frac{Ni \cdot (P - PETc) + 10 \cdot UN}{Nw \cdot (1-f) - Ni} \qquad (15)$$

where,

P [cm/year] annual rain height
PETc [cm/year] annual crop evapotranspiration
Nw [mg/l] nitrogen concentration in the sewage
f nitrogen percentage lost
Ni [mg/l] nitrogen concentration in the filtrate
UN [kg/ha /year] nitrogen demand from plants

The following assumptions are made for estimating the nitrogen-based water needs, Qwn.

- The nitrogen concentration in the filtrate, Ni, was assumed equal to 5% of the nitrogen concentration in the sewage (see Equation 16):

$$\mathrm{Ni} = \mathrm{Nw} \cdot 5\% \qquad (16)$$

- The percentage of nitrogen, f, lost due to nitrification / denitrification, volatilization and soil storage for 3rd class wastewater is equal to 0.15 during the summer months and 0.10 for the winter months, according to the following Table 2.5.

$$f_{NS}=0.15$$
$$f_{Nw}=0.10$$

Table 2.5 Percentage of nitrogen, f, lost.

Percentage of nitrogen, f, lost		
Wastewater type	Warm climate	Cold climate
Strong	0.80	0.50
1st level	0.50	0.25
2nd level	0.25	0.10-0.25
3rd level	0.15	0.10

Based on the above assumptions, the nitrogen-based water needs, Lwn, is calculated in cm / day. Based on the area A (m^2) each crop occupies, the supply of the nitrogen demand, Qwn (m^3 / day) is (see Equation 17):

$$Qwn = Lwn \cdot A \cdot 0.01 \qquad (17)$$

The daily design demand, Qd, for each crop is the minimum between Qwn and Qw, while the total Qd is calculated as the sum of the individual crop design demands.
The optimum content is the one that the nitrogen-based water demand supply has the smallest deviation from the water demand.
The total design demand, ΣQd, is the sum of every crop design demand Qd.

Total design demand including losses of the system

During the design part, the efficiency of the system is not possible to be determined in advance. For this reason, indicative efficiency values are used from literature (see Table 2.6), in order to estimate the distribution efficiency, Ed, and the application efficiency, Ef.

Table 2.6 Efficiency coefficients of irrigation methods and network distribution.

Network type	Maintenance and Operation	Distribution Efficiency, Ed
Surface	Very good to excellent	0.60-0.75
	Satisfying	0.50-0.60
	Imperfect	0.35-0.50
	Bad	0.20-0.35
Under pressure	Very good to excellent	0.80-0.95
Irrigation method		Application Efficiency, Ef
Basin		0.60-0.80
Border		0.60-0.75
Furrow		0.50-0.75
Sprinkler systems		
Classic system		0.60-0.80
Moving Sprinkler of high pressure		0.55-0.75
Moving irrigation line		0.75-0.90
Pivot		0.75-0.90
Drip		0.80-0.96

The design demand including the two applied irrigation methods of the fields, Qd2 (m^3/day), is obtained by dividing the corresponding efficiency coefficient, Ef (see Equation 18):

$$Qd_2 = \frac{Qd}{Ef} \qquad (18)$$

The irrigation methods applied in the study area are the drip irrigation and the furrow irrigation which according to the above Table correspond to an efficiency factor Ef, 0.9 and 0.65 each one. Both irrigation methods are applied to half of the irrigated area respectively. That is why half of the total design demand ΣQd is divided by the furrow irrigation efficiency factor Ef, 0.65 and the rest of it with the drip irrigation efficiency factor Ef, 0.9.
Then, in order to estimate the final daily demand supply of the system Qtotal (m^3/day), the daily demand Qd2 (m^3/day) is divided by the efficiency coefficient of the distribution network, Ed, where according to the relevant table, an open distribution network with a satisfactory operation equals to 0.6 (see Equation 19).

$$Qtotal = \frac{Qd2}{Ed} \qquad (19)$$

Results

Figures 2.12 to 2.19 depict the two different demands for each of the three available scenarios. It can be observed that the lowest the nitrogen content is, the highest the water demand based on nutrient needs gets, unlike the water demand which is stable whatever the nutrient content in the water. The nitrogen-based demand supply with the smallest deviation from the water demand is the one that corresponds to the second scenario, the highest nitrogen content, (20 mg/l) and is the one selected between the three as the optimal. Consequently, the resulting design supply is the Qd_2.

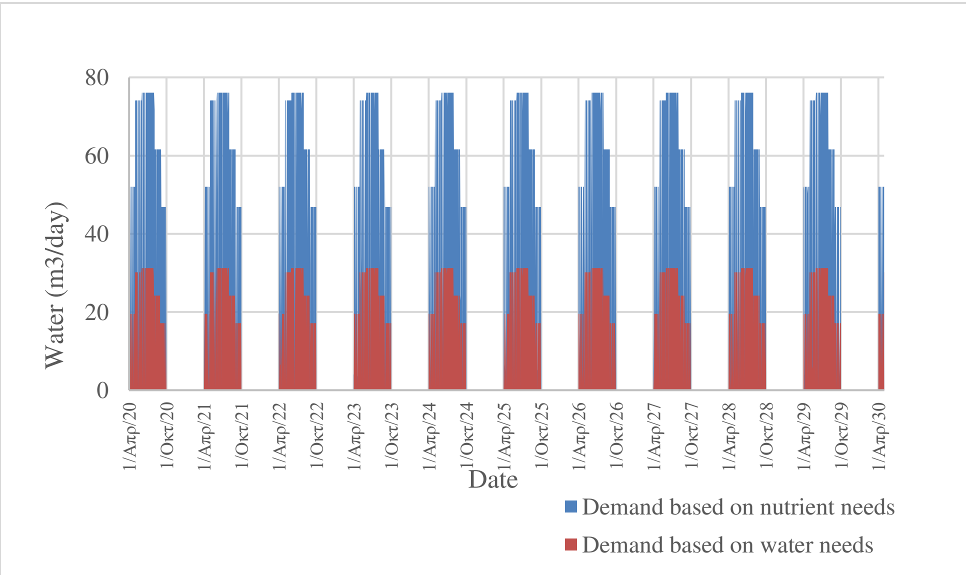

Figure 2.12 Demands based on 1st scenario of contents for the period 2019-2030

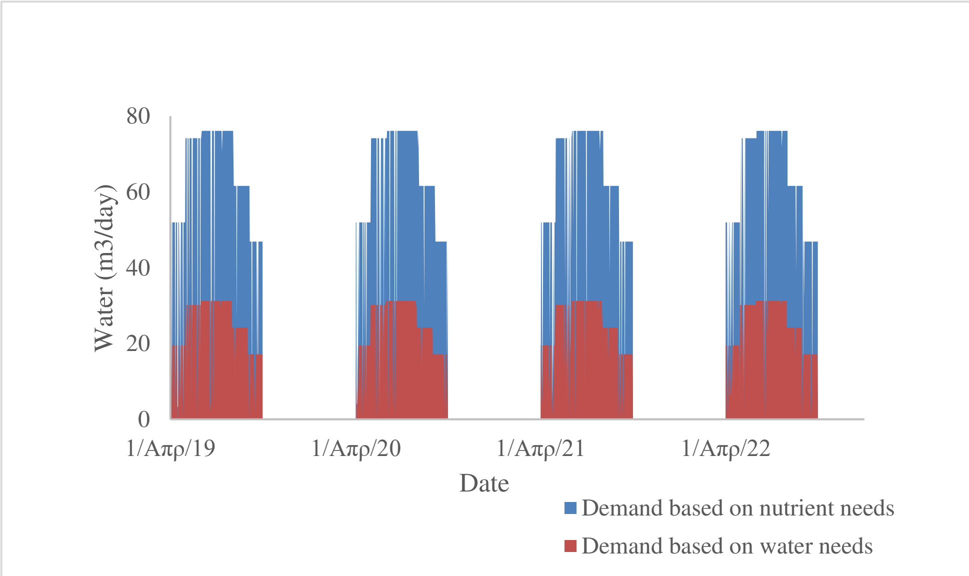

Figure 2.13 Demands based on 1st scenario of contents for the period 2019-2022

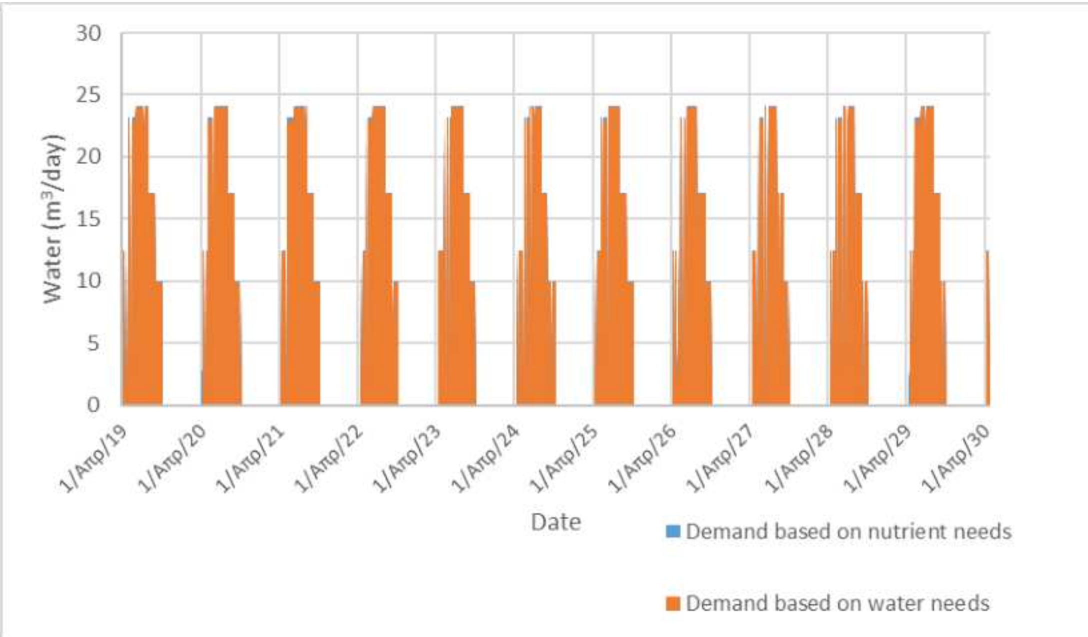

Figure 2.14 Demands based on 2nd scenario of contents for the period 2019-2030

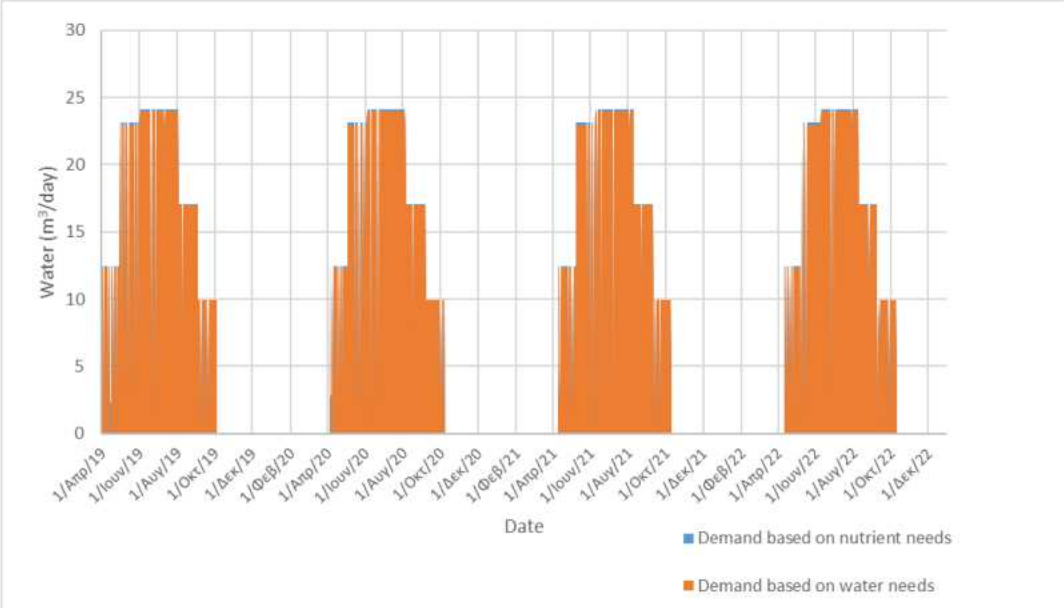

Figure 2.15 Demands based on 2nd scenario of contents for the period 2019-2022

Figure 2.16 Demands based on 3rd scenario of contents for the period 2019-2030.

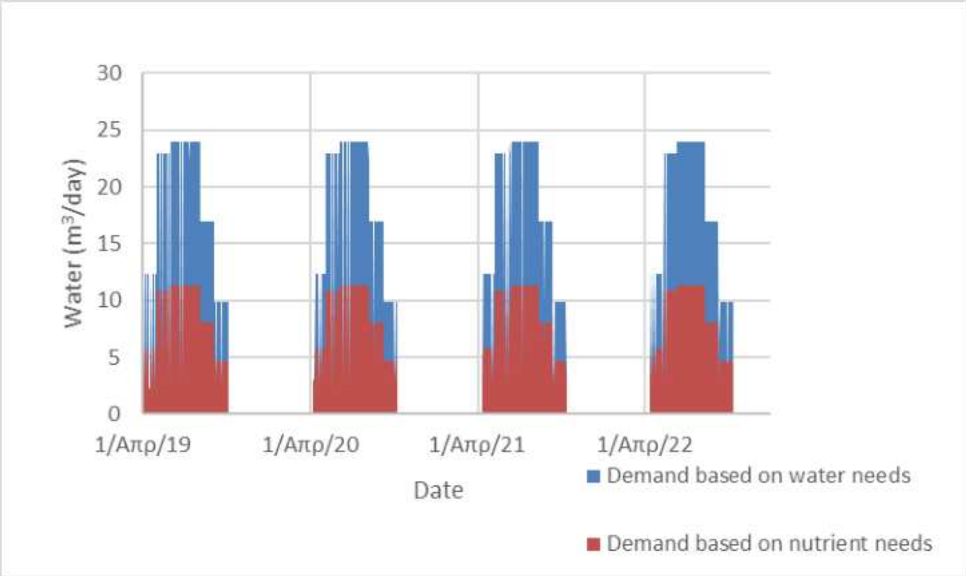

Figure 2.17 Demands based on 3rd scenario of contents for the period 2019-2022

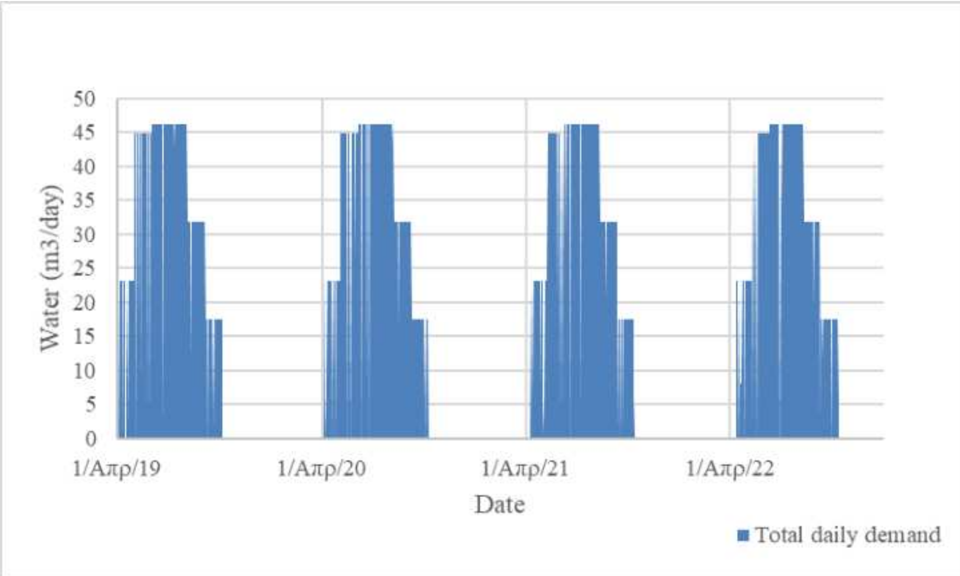

Figure 2.18 Total daily demand- Available winter supply for the period 2019-2030

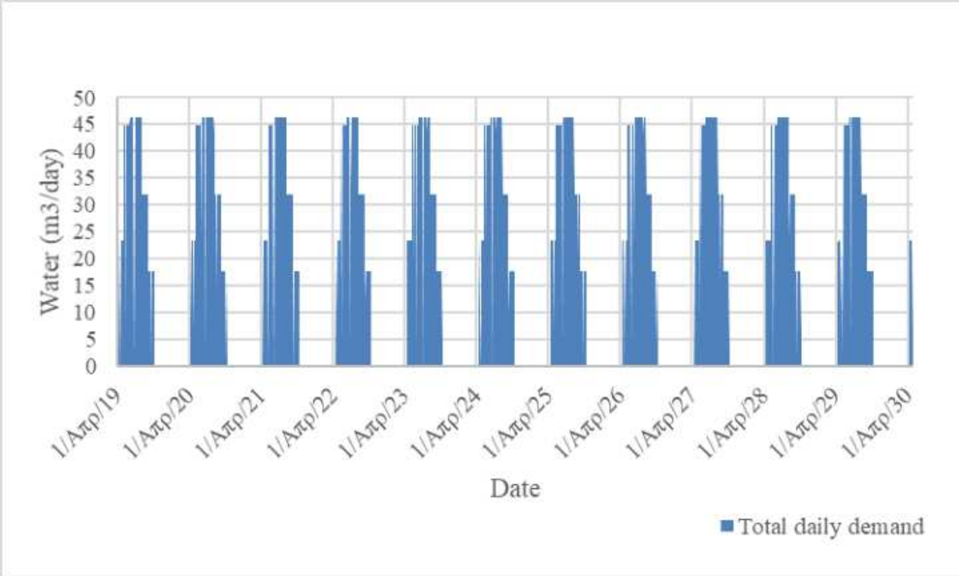

Figure 2.19 Total daily demand- Available winter supply for the period 2019-2022

Obviously, according to the above graph, the available supply is sufficient during the summer months and not sufficient for every winter month of the 12 years of forecast.

Estimation of crop coefficients and nitrogen needs

Different crops have different water and nutriend demands. These are expressed through crop coefficients and nitrogen needs, see Table 2.7.

Conclusions

To conclude, according to the methodology the water daily demand based on water needs, which resulted using the empirical Blaney-Criddle method, depends on the temperature factor, exclusively, contrasted to the water demand based on nutrient needs which, mainly, depends on the temperature and the nitrogen content in the supplied water, according to the slow filtration method. Thus, the demand based on nutrient needs is different for each scenario. Low content of nitrogen in the supplied water results in high water demand in order for the nutrient needs of the crops to be covered.
The most efficient solution, among the three scenarios, is the one by which the two different demands converge the most. This happens on the second scenario and so this is the one suggested to be implemented. In addition, it may also be observed that the total demand is fully covered during the summer months by the available water supply contrasted to the available supply during the winter months. That is why a construction of a dam is proposed so that the extra summer water can be stored and used when it is necessary.

Table 2.7 List of crops planted with crop coefficient kc and annual Nitrogen needs

			kc						N (kg/ha/year)
TREES (edible)		Quantity	April	May	June	July	August	September	
Castanea sativa (edible nuts)	Chestnut	10	1	1.15	1.25	1.25	1.25	1.2	100
Citrus aurantiifolia	key lime	4	0.75	0.75	0.7	0.7	0.7	0.7	200
Citrus limon (L.)	Lemon	2	0.75	0.75	0.7	0.7	0.7	0.7	200
Citrus maxima	Pomelo	2	0.75	0.75	0.7	0.7	0.7	0.7	170
Citrus reticulata	Mandarine	2	0.55	0.5	0.5	0.5	0.5	0.6	190
Eriobotrya japonica	Loquat	2	0.6	0.6	0.6	0.6	0.6	0.6	100
Ficus carica	Fig	13	0.45	0.6	0.7	0.7	0.7	0.7	220
Malus domestica	Apple	10	1	1.15	1.25	1.25	1.25	1.2	170
Morus nigra / alba	Mulberry	1	0.3	0.3	1.05	1.05	1.05	1.05	550
Persea americana	Avocado	3	0.6	0.85	0.85	0.85	0.75	0.75	135
Prunus avium	Cherry	2	1	1.15	1.25	1.25	1.25	1.2	1000
Prunus dulcis	Almond	12	0.4	0.4	0.9	0.9	0.9	0.65	100
Punica granatum	Pomegranate	13	0.6	0.6	0.6	0.6	0.6	0.6	111
Olea europea	Olive	13		0.25	0.35	0.45	0.45	0.3	1kg/tree/year
TREES (non-edible)									
Corylus maxima		6	0.6	0.6	0.6	0.6	0.6	0.6	100
Laurus nobilis	Laurel	26	0.6	0.6	0.6	0.6	0.6	0.6	100
Moringa oleifera	Moringa	8	0.6	0.6	0.6	0.6	0.6	0.6	100
Quercus ithaburensis	Tabor oak+	2	1	1.15	1.25	1.25	1.25	1.2	100
Olea oleaster	wild oliv	3		0.25	0.35	0.45	0.45	0.3	1kg/tree/year

		kc*						N (kg/ha/year)
AROMATIC PLANTS	Quantity	April	May	June	July	August	September	
Mentha spicata	700	0.6	0.6	0.6	0.6	0.6	0.6	75
Pimpinella anisum	2400	0.6	0.6	0.6	0.6	0.6	0.6	90
Origanum vulgare	60	0.6	0.6	0.6	0.6	0.6	0.6	80
Satureja Thymbra	100	0.6	0.6	0.6	0.6	0.6	0.6	60
Echinacea	1500	0.6	0.6	0.6	0.6	0.6	0.6	150
Melissa officinalis	1500	0.6	0.6	0.6	0.6	0.6	0.6	150
Valeriana officinalis	400	0.6	0.6	0.6	0.6	0.6	0.6	150
Lavandula officinalis	15	0.6	0.6	0.6	0.6	0.6	0.6	63.6
CROPS								
Zea Mays	4000	0.3	1.2	1.2	1.2	0.6		109
SHRUBS								
Agave americana (Sisal)	10	0.6	0.6	0.6	0.6	0.6	0.6	75
Juniperus communis	2	0.6	0.6	0.6	0.6	0.6	0.6	150
Albizia julibrissin	1	0.6	0.6	0.6	0.6	0.6	0.6	100
Lavandula angustifolia	760	0.6	0.6	0.6	0.6	0.6	0.6	63.6

*for the crops which their kc could not be found through research of bibliography, an assumption of a standardized kc equal to 0.6 for the whole irrigation period has been made.

2.2 HYDRO 3 and HYDRO 4 (Mykonos)

HYDRO 3 and HYDRO 4 are located in Ano Mera, Mykonos Island, and covers about 0.4 ha and 0.2 ha of land area, respectively. The highly touristic nature of Mykonos Island is definitely a very important factor for the setup of the HYDRO systems that influence also the choice of plants to be cultivated there. Moreover, as hotels and resorts situated on the island are high consumers of the freshwater resources (even high amount of water is being imported to the island) it makes the use of fresh water in agriculture a challenge. Therefore, these two HYDRO systems depend on rainwater harvesting/collecting systems and reuse these reserves for the cultivation of plants (in mono-farming system – MF) forming an added value to the island.

2.2.1 Community engagement at Mykonos

The community engagement in Mykonos Island has two main objectives; 1st is to gain interest of the local community in the two HYDRO systems and, also to build social responsibility towards water consumption and reuse of water on the island. In that regard, in T4.1 (community engagement task) planned and performed meetings with some of the stakeholder in Mykonos, such as the mayor and the municipality council, which included members representing different local communities in Mykonos. These meetings/interviews were concluded that the local community is really interested in HYDROUSA technologies and that HYDRO 3 and HYDRO 4 systems could bring solutions for water reuse in agriculture innovations. The 2nd objective of local community engagement is to setup user requirements and user analysis for the automation systems of HYDRO 3 and HYDRO 4. This will be done through co-creation workshop that is planned to take place after the installation of the systems for demonstration purposes.

As described in the DoA, HYDRO 3 systems will be used to cultivate 0.4 ha of Oregano, while HYDRO 4 will be used to cultivate 0.2 ha of Lavender plants. These two plants are considered dry-soil herbs that could tolerate drought conditions and produce high-value essential oils with competitive prices under the water availability of the systems. Oregano has been used for centuries for a variety of its health improving properties. It contains multiple antibacterial and antimicrobial properties. It has been used to relieve coughs, reduce body odour, soothe digestive muscles, and lower blood pressure. Oregano is a strong antioxidant, with high levels of beneficial acids and flavonoids. Lavender is a perennial plant that can live up to 20 years, if the conditions are optimum. It produces purple flowers, which contain high levels of essential oil. Mediterranean countries (Italy, France, and Spain) have long tradition in growing lavender. Nowadays, countries such as USA, Canada, Japan, Australia and New Zealand are also considerable commercial lavender producers. The essential oil of lavender is recognized globally as a respected commodity. It has several medicinal and other uses. It also has remarkable antiseptic and antimicrobial action. For these features, the essential oils of these two crops will be considered a high added value to the island.

2.2.2 Soil analysis

In this section, the results of the soil analysis will be presented (see Table 2.8 and 2.9), carried out in order to check the suitability of the selected areas for both the Technical Design of the Underground Rainfall Collector and the irrigation project, as well as for fertilization recommendations.

Table 2.8 Soil analysis results of oregano cultivation land area

<table>
<tr><td rowspan="2">Particle size:</td><td colspan="5">Light, warm, dry soil, suffer from low nutrients that are washed away by rain, has reduced water and nutrient retention capacity
It has good ventilation and drainage conditions are created for plant growth. The soil must be sufficiently irrigated and fertilized at frequent and small doses</td></tr>
<tr></tr>
<tr><td rowspan="2">pH :</td><td colspan="5">pH is suitable for cultivation Oregano</td></tr>
<tr><td colspan="5">Cation exchange capacity produces close to 100% of nutrients</td></tr>
<tr><td>Electrical Conductivity:</td><td>Very low</td><td colspan="4">Possible appearance of deficiencies. Poor soil with low microbial activity</td></tr>
<tr><td>Total Calcium Carbonate:</td><td>Very low</td><td colspan="4">It is suggested to add calcium</td></tr>
<tr><td>Active Active Calcium Carbonate:</td><td>Average Value</td><td colspan="4">Soil suitable for almost all cultivated species-</td></tr>
<tr><td>Organic matter:</td><td>Very Low</td><td colspan="4">It is recommended to add, 40 t/ha of well decomposition animal manure or 3,500 – 3,700 kg per ha of compost, in winter or at least one month before sowing or planting. Reduce the nitrogen dose by 1.5 - 2 units per tonn of manure added</td></tr>
<tr><td colspan="2">C.E.C. (Cation Exchange Capacity):</td><td colspan="4">Low CEC. Possible to develop deficiencies in potassium (K+), magnesium (Mg^{2+}) and other cations</td></tr>
<tr><td colspan="2">C/N ratio:</td><td colspan="4">-</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td></td><td colspan="2">Recommended fertilizing</td><td colspan="3">Recommended fertilizer</td></tr>
<tr><td></td><td>Dose (Units)</td><td>Application method of fertiliser</td><td>Type of fertilizer</td><td colspan="2">Dose (kg/ha)</td></tr>
<tr><td rowspan="2">Nitrogen (N)</td><td colspan="2">Very Low content</td><td>Recommended dose of Nitrogen</td><td>0.00</td><td>Units</td></tr>
<tr><td colspan="2">According to the instructions in the field “Organic matter"</td><td>Organic matter</td><td colspan="2"></td></tr>
<tr><td></td><td colspan="5">Low content</td></tr>
</table>

Available Phosphorus (P)	**18.00**	It is applied at the end of the winter to early spring with a depth of at least 15-20 cm. Linear application during sowing facilitates the intake of the nutrient.	Triple superphosphate (0-46-0)	**391**
Available Potassium (K)	***Marginal content***			
	8.00	It is applied at the end of the winter with a depth of at least 10 cm.	Potassium sulphate (0-0-50)	**160**
Available Magnesium (Mg)	**Very high content sufficient for more than 4 years. Can cause K deficiency and in sensitive crops and Ca**			
	Because of the high amount of magnesium it is proposed to increase the organic matter as described in the corresponding field and to apply crop rotation. In addition, the addition of calcium sulphate (gypsum) in the amount of 3,000 – 4,500 kilograms per ha could help the action of organic matter and crop rotation.			
Available Calcium (Ca)	***Low Content. It is recommended to add calcium***			
	It is proposed to improve the soil by adding calcium, $CaCO3$, CaO or $Ca (OH) 2$ compounds. Together with calcium, dolomite (magnesium) is added in proportion (10% -25%). It is also recommended to re-test the pH every two years			
	It is applied by spreading and incorporating at a depth of 20 cm from autumn to the end of winter		Calcium carbonate ($CaCO3$)	**5,000.0 kg/ha**
Iron (Fe)	***Very high***			
Zinc (Zn)	***Sufficient content for 1-2 years***			
Manganese (Mn)	***Very low***			
	1 Unit	It is applied by integration into the soil close to the planting line	Manganese sulphate 36% granular	**31 kg/ha**
Cooper (Cu)	***Very low***			
	0.4 Units	It is applied by integration into the soil before sowing or planting (depth 0-20 cm).	Hydrate copper sulphate ($CuSO_4$ $5H_2O$) 25% crystal (blue)	**16 kg/ha**
Boron (B)	***Very low***			

	0.7 Units	It is applied by integration into the soil (10-15 cm) early in spring before plant growth begins. Avoid very premature application due to leaching	Borax 11,5%	**62 kg/ha**

Table 2.9 Soil analysis results of lavender cultivation land area

<table>
<tr><td rowspan="1">Particle size:</td><td colspan="4">Light, warm, dry soil, suffer from low nutrients that are washed away by rain, has reduced water and nutrient retention capacity
It has good ventilation and drainage conditions are created for plant growth. The soil must be sufficiently irrigated and fertilized at frequent and small doses</td></tr>
<tr><td rowspan="2">pH :</td><td colspan="4">pH is suitable for cultivation of Lavender</td></tr>
<tr><td colspan="4">Cation exchange capacity produces close to 100% of nutrients</td></tr>
<tr><td>Electrical Conductivity:</td><td>Very low</td><td colspan="3">Possible appearance of deficiencies. Poor soil with low microbial activity</td></tr>
<tr><td>Total Calcium Carbonate:</td><td>Very low</td><td colspan="3">It is suggested to add calcium</td></tr>
<tr><td>Active Active Calcium Carbonate:</td><td></td><td colspan="3"></td></tr>
<tr><td>Organic matter:</td><td>Very Low</td><td colspan="3">It is recommended to add, 40 t/ha of well decomposition animal manure or 3,500 – 3,700 kg per ha of compost, in winter or at least one month before sowing or planting. Reduce the nitrogen dose by 1.5 - 2 units per tonne of manure added</td></tr>
<tr><td colspan="2">C.E.C. (Cation Exchange Capacity):</td><td colspan="3">Low CEC. Possible to develop deficiencies in potassium (K^+), magnesium (Mg^{2+}) and other cations</td></tr>
<tr><td colspan="2">C/N ratio:</td><td colspan="3">-</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td></td><td colspan="2">Recommended fertilizing</td><td colspan="2">Recommended fertilizer</td></tr>
<tr><td></td><td>Dose (Units)</td><td>Application method of fertilizer</td><td>Type of fertilizer</td><td>Dose (kg /ha)</td></tr>
</table>

This project has received funding from
the European Union's Horizon 2020
Research and Innovation Programme
under Grant Agreement No 776643

<table>
<tr><td rowspan="2">Nitrogen (N)</td><td colspan="2">Very Low content</td><td>Recommended dose of nitrogen</td><td>0.00</td><td>Units</td></tr>
<tr><td colspan="2">According to the instructions in the field “Organic matter"</td><td>Organic matter</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Available Phosphorus (P)</td><td colspan="5">Low content</td></tr>
<tr><td>13</td><td>It is applied at the end of the winter to early spring with a depth of at least 15-20 cm. Linear application during sowing facilitates the intake of the nutrient.</td><td>Triple superphosphate (0-46-0)</td><td colspan="2">283</td></tr>
<tr><td rowspan="3">Available Potassium (K)</td><td colspan="5">Marginal content</td></tr>
<tr><td colspan="5">Because Magnesium is more than 3 times more than potassium, it is advisable to incorporate 3-5 units of potassium</td></tr>
<tr><td>5.00</td><td>It is applied at the end of the winter with a depth of at least 10 cm.</td><td>Potassium sulphate (0-0-50)</td><td colspan="2">100</td></tr>
<tr><td rowspan="2">Available Magnesium (Mg)</td><td colspan="5">Very high content sufficient for more than 4 years. Can cause K deficiency and in sensitive crops and Ca</td></tr>
<tr><td colspan="5">Because of the high amount of magnesium it is proposed to increase the organic matter as described in the corresponding field and to apply crop rotation. In addition, the addition of calcium sulphate (gypsum) in the amount of 3000 - 4500 kilograms per ha could help the action of organic matter and crop rotation.</td></tr>
<tr><td rowspan="3">Available Calcium (Ca)</td><td colspan="5">Low Content. It is recommended to add calcium</td></tr>
<tr><td colspan="5">It is proposed to improve the soil by adding calcium, CaCO3, CaO or Ca (OH) 2 compounds. Together with calcium, dolomite (magnesium) is added in proportion (10% -25%). It is also recommended to re-test the pH every two years</td></tr>
<tr><td colspan="2">It is applied by spreading and incorporating at a depth of 20 cm from autumn to the end of winter</td><td>Calcium carbonate (CaCO3)</td><td colspan="2">5,000.0 kg/ha</td></tr>
<tr><td></td><td colspan="2">OR fertilizing with 10-20 liters/ha or foliar applications with 200-400 ml/100 liters of water</td><td>Ca—EDTA</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Iron (Fe)</td><td colspan="5">Very high. Lime, aeration and soil drainage measures are proposed</td></tr>
<tr><td></td><td>It is recommended to add calcium</td><td>-</td><td colspan="2"></td></tr>
<tr><td>Zinc (Zn)</td><td colspan="5">Sufficient content for 1-2 years</td></tr>
</table>

Manganese (Mn)	***Sufficient content***			
Cooper (Cu)	***Sufficient content***			
Boron (B)	***Very low***			
	0.8 Units	It is applied by integration into the soil (10-15 cm) early in the spring before plant growth begins. Avoid very premature application due to leaching	Borax 11.5%	**71 kg/ha**

2.2.3 Irrigation

a) Deficit Irrigation

The Regulated Deficit Irrigation (RDI) method is an irrigation programming technique originally developed for fruit orchards. RDI usually refers to any irrigation strategy that maintains plants to a certain degree of deficit irrigation for some specific phases of the growing season, with the aim of controlling reproductive growth and development, vegetative growth, and improved Water Use Efficiency - (WUE).

According to RDI, the plant's aqueous state is maintained within the predetermined deficit limits (in relation to maximum aquatic potential), during certain stages of seasonal growth, usually when the growth of the fruit is less sensitive to water reductions.

The basis behind this practice is that optimization of fruitfulness and quality will be achieved by maintaining the balance between energy and productive potential.

The successful implementation of this system requires fully developed plants with an extensive and deep root system. Under such conditions, the rate of change in plant water status is slow, making safer and more controllable the application and maintenance of the desired water deficit levels.

The RDI irrigation methods are based on the continuous monitoring of some indicative physiological parameters of the plant's water stress.

Irrigation should only be applied when such a parameter falls below a certain threshold. To prioritize more efficient use of water for maximum performance, irrigation should only be applied when parameter values fall below a certain threshold value (for example, when GS values range between 0.05 and 0.15 mol of $H_2O/m^2.s$).

According to the current knowledge about the effects of water stress on photosynthesis, yield and quality, by keeping plants at these floating values we can have:

- Maximum effectiveness in water use.
- Immediate resumption of photosynthetic function during re-irrigation.
- Relatively stable area yields and preservation of optimal plant characteristics.

b) Determination of actual water needs

The actual needs of the crops in the study area in the irrigation water of the project are calculated according to the K.Y.A. with no. (Government Gazette 428 / B / 2-61989), which establishes the minimum and maximum quantities necessary for the rational use of water in irrigation. For the calculation of irrigation water needs, the empirical method of Blaney - Criddle is applied, which gives satisfactory results in areas with limited meteorological data (temperature, rainfall) compared to other more precise methods. The application of this method to calculate the water needs of crops in an area is based on the average monthly temperature, monthly rainfall and daytime hours of the irrigation period.

According to the K.Y.A., the crop categories are defined on the basis of a plant factor K and more specifically they refer to eight (8) categories of phytotoxic factor, except for dry crops (Table 2.11), while the limits for the use of irrigation water have been defined per crop category and per water department (in $m^3/1000\ m^2$/month) for each given month of the irrigation period from February to December (see Table 2.12).

The Blaney - Criddle method is formulated by an empirical relationship, which calculates seasonal evapotranspiration, from germination to crop harvesting, as a function of the mean monthly air temperatures (T) during this period, of a factor (p) expressing the duration of the day of each month as a percentage of the corresponding annual duration and a planting factor (K) that is characteristic of each crop.

Analytically, only the average monthly temperature and latitude of the basin are required to calculate the Blaney - Criddle evapotranspiration rate. In this method the monthly consumption of plants in water (evapotranspiration) in mm or in m^3 / 1.000 m^2 is mathematically expressed by the ratio presented in Equation 20:

$$\boldsymbol{U = Kc \cdot f} \qquad (20)$$

Where:

Kc: empirical water consumption factor depending on the species and the germination period of the crop and f: monthly water consumption factor determined by Equation 21:

$$f = \frac{(T+18)}{2.2} * p \qquad (21)$$

T: the average monthly temperature in ^oC and

p: the average monthly hourly rate (based on latitude). P is calculated when the values in Table 2.10 are multiplied by the number of days of each month. It is given as a function of the month and the latitude of the area.

For the calculations, the northern latitude corresponding to the point where the field is located equals to 37°26'. Based on this value of the northern latitude, the values of the coefficient p were determined (see Table 2.10). In order to calculate the monthly needs of each crop separately, the reference cultivation evapotranspiration value should be multiplied by the factor Kc (see Table 2.7) as can be seen in Equation 22.

$$U_{month} = f * K \qquad (22)$$

Table 2.10 Monthly rate of daytime hours as a percentage of the total day of the year for geographic northern hemisphere - Factor p

Latitude	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	TOTAL
34	7.10	6.91	8.36	8.80	9.71	9.70	9.88	9.33	8.36	7.90	7.02	6.92	100
35	7.05	6.88	8.35	8.82	9.76	9.77	0.93	9.37	8.36	7.88	6.97	6.86	100
36	6.99	6.86	8.35	8.85	9.81	9.83	9.99	9.40	8.36	7.85	6.92	6.79	100
37	6.93	6.83	8.34	8.87	9.87	9.89	10.05	9.44	8.37	7.82	6.87	6.72	100
38	6.78	6.79	8.34	8.90	9.92	9.95	10.10	9.47	8.38	7.80	6.82	6.66	100
39	6.82	6.76	8.33	8.93	9.97	10.02	10.16	9.51	8.38	7.77	6.77	6.48	100
40	6.76	6.72	8.33	8.95	10.02	10.08	10.22	9.54	8.38	7.75	6.72	6.52	100
41	6.69	6.69	8.32	8.98	10.08	10.15	10.29	9.56	8.39	7.73	6.67	6.45	100
42	6.62	6.65	8.31	8.00	10.14	10.21	10.35	9.62	8.40	7.70	6.62	6.38	100

(Source: Theoharis M., 1997)

The net water consumption (N) of the crops (N = U-R ') results from the water consumption, after deducting the useful rainfall (R', see Equation 23) which are determined by the empirical relation:

$$R' = R - \left(c + \frac{R}{8}\right) \qquad (23)$$

Where:

R′: the height of useful rainfall in mm

R: the actual rainfall height in mm and c: a special factor that takes values from 12 to 15 and which for the particular area is taken to be 12.

The following data and assumptions were used for the calculation of water crop requirements:

- The average monthly temperatures (T °C) and the actual monthly rainfall (R) were obtained according to the records of the meteorological station of Mykonos.
- The values of the coefficient p from the relevant Table Table 2.10 and for the latitude 37° 26 '. The values of the empirical coefficient K by category of crops (according to the KYA No Φ.16 / 6631/1989 (Government Gazette 428 / B / 2-6-1989)), constitute the average of the coefficients of the different stages of development of each crop and are as follows

Table 2.11 Values of the planting coefficient K for different crop categories

Category I	**Category II**	**Category III**	**Category IV**
K = 0.55	K = 0.60	K = 0.65	K = 0.70
Citrus	Tobacco east. type	Fruit trees	Tobacco west. type
Olives	Hay	Tree nuts	Horticultural
Vines		Legumes	Green groceries
Aromatic		Cotton	Potatoes
		Strawberries	Sugar beet
		Flowers	Sunflower
		Avocado	Peanut
Category V	Category VI	Category VII	Category VIII
K = 0.75	K = 0.80	K = 0.85	K = 1.20
Cereals	Clover	Alfalfa	Rice
Corn	Art. Grasslands		
Sorghum			
Manicured	Kiwi		
Poplar			

(*Source: KYA with F.16 / 6631/1989 (FEK 428 / B / 2-6-1989)*)

Table 2.12 Irrigation water application limits per m^3 /0.1 ha/month for the Aegean Islands Water Dept - South Section

Category	Limits of values	April	May	June	July	August	September
I	Min	66	85	96	99	93	77
	Max	77	102	115	118	113	93
	M.O.	**71.5**	**93.5**	**105.5**	**108.5**	**103**	**85**
II	Min	72	93	105	108	102	84
	Max	84	111	126	129	123	102
	M.O.	**78**	**102**	**115.5**	**118.5**	**112,5**	**93**
III	Min	78	101	114	117	110	91
	Max	91	120	136	140	133	110
	M.O.	**84.5**	**110.5**	**125**	**128.5**	**121.5**	**100.5**
IV	Min	84	108	122	126	119	98
	Max	98	129	147	150	143	119
	M.O.	**91**	**118.5**	**134.5**	**138**	**131**	**108.5**
V	Min	90	116	131	135	127	105
	Max	105	139	157	161	154	127
	M.O.	**97.5**	**127.5**	**144**	**148**	**140,5**	**116**
VI	Min	96	124	140	144	136	112
	Max	112	148	168	172	164	136
	M.O.	**104**	**136**	**154**	**158**	**150**	**124**
VII	Min	102	132	149	153	144	204
	Max	119	157	178	183	174	246
	M.O.	**110.5**	**144.5**	**163.5**	**168**	**159**	**225**
VIII	Min	144	186	210	216	204	168

Max	163	222	252	258	246	204
M.O.	**153.5**	**204**	**231**	**237**	**225**	**186**

(Source: KYA with No Φ 66/6631 / 1989 (Government Gazette 428 / B / 2-6-1989))

The duration of the irrigation period is from April to mid August. During the early stages of crop growth, due to the fact that the soil moisture level is relatively high due to winter and spring rainfall, and therefore a part of their water needs is covered by these stocks, smaller amounts are anticipated than those specified in the Blaney - Criddle method.

For the calculation of the net and total water needs of the crops in the project area (see Table 2.13), the calculated net monthly water consumption quantities of the crops are multiplied by the corresponding coefficient representing the percentage of days of the irrigation month. The percentage of the length of the month in which each crop is irrigated is calculated. That is, for the months when irrigation is applied for only a few days, the irrigation needs are calculated as the percentage of the irrigation days (this is the case for the first and last months of the irrigation period, while for the intermediate the needs are estimated at 100 %).

The maximum daily irrigation time is calculated for 18 and 24 hours a day.

Table 2.13 Calculation of crop needs in water according to the Blaney - Griddle method

Crop:	Oregano →	K =	0.55

Month	Average Monthly Temperature	Percentage of hours of the Day	$f = \frac{(T+18)}{2.2} * p$	Average monthly rainfall (10years) (mm)		Monthly Evapotranspiration (mm)	Net Water Consumption (mm)
	T (°C)	P	F	*Actual R*	Useful R'	U = K*f	N = U-R'
January	12.6	6.9	53.3	64.6	44.55	29.3	-15.22
February	13.4	6.8	54.1	65.1	44.97	29.8	-15.19
March	14.3	8.3	68.3	36.1	19.62	37.6	17.97
April	16.6	8.9	78.2	15.4	1.51	43.0	41.50
May	20.2	9.9	96.1	7.4	-5.51	52.8	58.35
June	23.7	10.0	105.3	4.6	-7.94	57.9	65.87
July	25.8	10.1	112.3	0.0	-11.98	61.8	73.76
August	25.8	9.5	105.3	0.1	-11.93	57.9	69.82
September	23.8	8.4	89.0	13.7	-0.05	48.9	48.98
October	20.0	7.8	75.2	26.8	11.49	41.4	29.90
November	17.2	6.8	60.9	31.6	15.65	33.5	17.87
December	14.2	6.7	54.4	48.2	30.18	29.9	-0.25
			Total	313.78	130.56	523.93	393.37

Crop	cultivation - irrigation Area		irrigation PERIOD	irrigation method		Losses to the network	0.00%
	(10*ha)	%	1/4 - 31/8	drip irrigation		Losses due to illegal supply	0.00%
oregano	4.00	100.00	K = 0.55	Degree of efficiency D.E.	99.85%	Losses due to application in the field	0.15%

Months												TOTAL
J	F	M	A	M	J	J	A	S	O	N	D	
Percentage of days of the month												
0.00	0.00	0.00	0.11	0.11	0.08	0.00	0.08	0.00	0.00	0.00	0.00	
Net Water Consumption (mm)												
-15.22	-15.19	17.97	41.50	58.35	65.87	73.76	69.82	48.98	29.90	17.87	-0.25	393.37
Net Water Requirements for Crop Irrigation (According to the Deficit Irrigation Method) (m³/0.1 ha)												
0.00	0.00	0.00	2.28	3.85	4.45	0.00	5.24	0.00	0.00	0.00	0.00	15.82
Total water requirements, including losses of transportation, distribution, filtration and evaporation in the field, and illegal water provision along the route in the irrigation network (m³/0,1 ha)												
0.00	0.00	0.00	2.29	3.86	4.45	0.00	5.24	0.00	0.00	0.00	0.00	15.84
Total annual water needs for the irrigation area (m³/0.4 ha)												63.36

By using the same calculation methodology and knowing that the standard k for lavender is 0.55 (same as oregano) the total annual water needs for the irrigation of 0.2 ha of lavender crop is presented below:

Crop	cultivation - irrigation Area		irrigation PERIOD	irrigation method		Losses to the network	0.00%
	(10*ha)	%	1/4-31/8	drip irrigation		Losses due to illegal supply	0.00%
lavender	2.00	100.00	K = 0.55	Degree of efficiency D.E.	99.85%	Losses due to application in the field	0.15%

J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
Percentage of days of the month												
0.00	0.00	0.00	0.00	0.13	0.13	0.13	0.13	0.07	0.06	0.00	0.00	
Net Water Consumption (mm)												
-15.22	-15.19	17.97	41.50	58.35	65.87	73.76	69.82	48.98	29.90	17.87	-0.25	393.37
Net Water Requirements for Crop Irrigation (According to the Deficit Irrigation Method) (m^3/0.1 ha)												
0.00	0.00	0.00	0.00	4.55	7.71	9.59	9.08	3.43	1.08	0.00	0.00	35.43
Total water requirements. including losses of transportation. distribution. filtration and evaporation in the field. and illegal water provision along the route in the irrigation network (m^3/0.1 ha)												
0.00	0.00	0.00	0.00	4.56	7.72	9.60	9.09	3.43	1.08	0.00	0.00	35.48
Total annual water needs for the irrigation area (m^3/0.2 ha)												70.97

a) Self-adjusting drip pipes

Drip irrigation is the method by which water is applied to selected field locations in the form of drops. In drip irrigation, water is provided to the area of the highest plant root activity and not to the entire stretch of the field. Basic components of the method are the drippers through which water is applied to the ground (see Figure 2.20).

A drip irrigation network includes

- the dispensers (drippers),
- the piping (main, secondary and side pipelines),
- the connection components (valves, taps, corners, connectors, etc.)
- the head or control center (filters, valves, pressure gauges, etc.)
- the pressure and supply source (e.g., pumping unit, the water mouth or irrigation head of the collective network of closed-circuit pipelines).

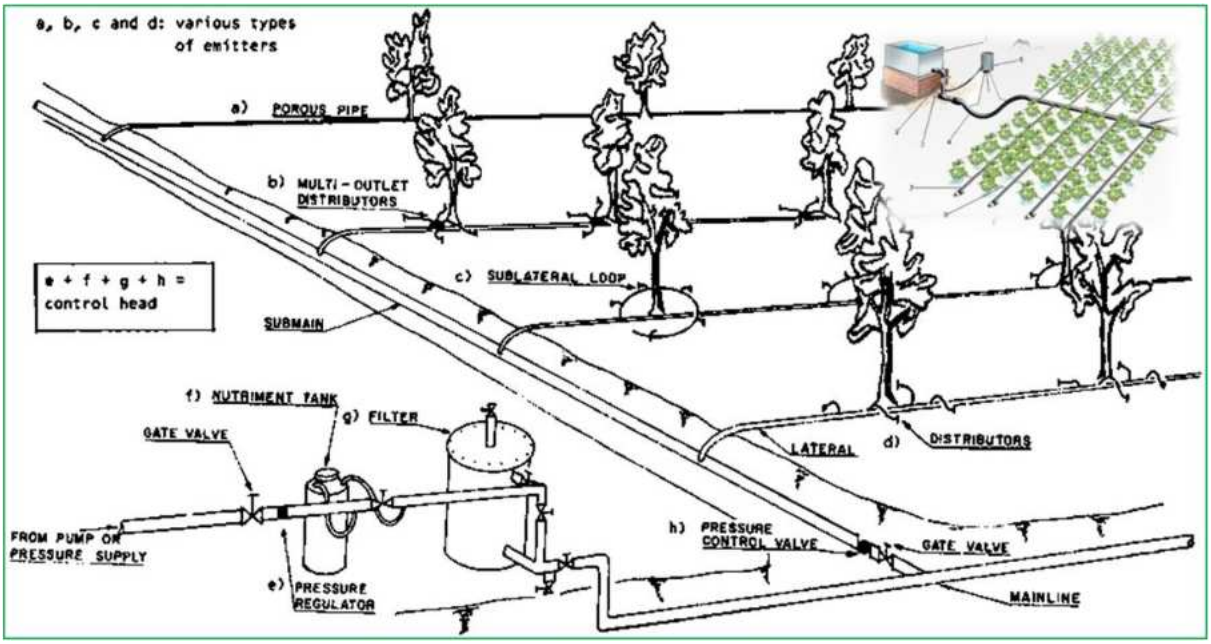

Figure 2.20 Drip irrigation

b) Self-adjusting irrigation drip pipes PC

Low density polyethylene (LDPE) drip pipes used in drip irrigation. They are pipes with built-in self-adjusting drippers in permanent positions.

It is recommended to use 16 mm diameter pipes at a distance of 40 cm between drips and a 2 liters water supply per hour for each dripper.

c) Moisture measurement in the field

Strain gauge (water potential measurement of soil)

Strain gauges measure the availability of water in the root system of plants (see also Figure 2.21). Strain gauges are designed for permanent installation on the ground. They have a transparent acrylic tube of various lengths (according to the cultivation). At the bottom of the strain gauge there is a porous ceramic capsule. It is a Ø25 pipe approximately bearing a porous cover at the bottom, filled with de-ionized water and it closes airtight at the top, while a manometer is fitted underneath the lid. It is installed according to the size of the pipe at depths of 30 cm, 55-60 cm or 90 cm. Its operation is simple: when the ground is dry, water is drawn from the instrument and the manometer records a high value. When the soil is wet, liquid returns to the instrument and the lowest value is recorded in the manometer.

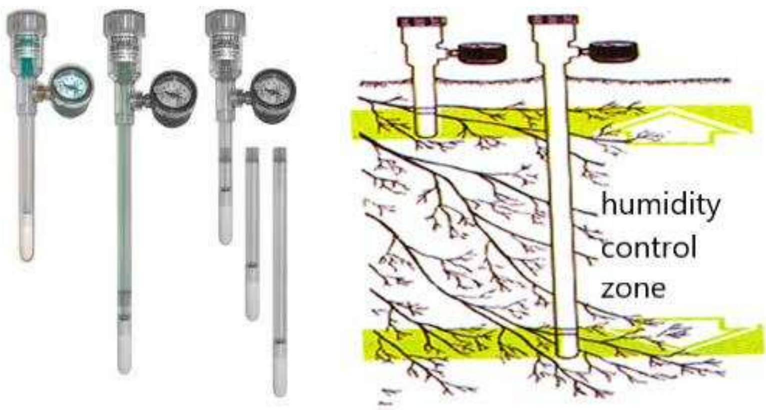

Figure 2.21 Strain gauge (measurement of water potential of the ground)

Manometric strain gauge. These are classic strain gauges with a clock-type manometer. It provides a direct indication of the soil's water potential. It cannot be controlled remotely.

Electronic strain gauge. Strain gauges with a pressure transducer for connection to a digital recorder.

Electronic Sensor of Water Potential of the Ground. It is an electronic method of measuring the water potential of the soil. It has an output for connection to a digital recorder.

Ground moisture meters

Ground moisture meters (see Figure 2.22) may remain for a short or long time in the ground, but may also remain permanently installed. They require calibration and can be connected to a portable direct soil moisture meter or to a digital datalogger

Figure 2.22 Ground moisture sensors

2.3 HYDRO 5 and HYDRO 6 (Tinos)

Tinos island is a point of attraction to tourists and the HYDROUSA project aims at providing added values to the island by introducing some unusual agricultural systems. The HYDRO 5 or also referred as "tropical greenhouse" is located on the water desalination facilities that are owned by the municipality of Tinos in Agios Focas. HYDRO 5 agricultural demo site is a classical greenhouse attached to a Mangrove-still desalination system. HYDRO 6 agricultural demo site is situated in Tinos Ecolodge. The Ecolodge of Tinos (ELT) is one of the main points of attraction in Tinos Island. It brings yearly hundreds of tourists who would like to spend time embracing nature and living the experience of living in a nature-based society. The business model that the Tinos Ecolodge is adopting is based on circular loops of water, energy, and food. Tourists who visit Ecolodge are interested to learn the meaning of growing plants and taking care of them and how these plants could grow using reused water and in soil that have been treated with a home-made compost. The agricultrural demo site 6 is based on HYDRO 6 water system. The HYDRO 6 water system is a mixture of different systems including rainwater harvesting, reclaimed wastewater and surface water. Therefore, a variety of plants are foreseen to be cultivated in this demo site. These plants include edible plants, plants for production of essential oils, functional plants, etc. The advantage of having these different water systems is to plant these varieties of plants to serve different purposes. Harvested rainwater, reclaimed wastewater, and collected surface water will be used to irrigate edible plants, herbal and medical plants. This business model will engage the community through different workshops, selling new products.

2.3.1 Community engagement at Tinos

In Tinos Island one co-creation workshop was held divided in two meetings (see Figure 2.23). The first took place in June 2019 at the old Town Hall with the intention to introduce HYDROUSA objectives, vision and actions plans to local stakeholders. During the three days visit, one-to-one interviews with local opinion makers and key stakeholders took place, understanding better the local challenges and opportunities. This first invitation was to intentionally meet local partners and the island's stakeholders to design the content for the second co-creative workshop. Impact Hub Athens members teamed up with alchemia-nova representatives and with the support of Tinos Municipality and Tinos Ecolodge invited interested individuals with local knowledge to re-imagine Tinos as a paradigm of sustainable development showcasing smart applications incorporating values of circular economy.

Farmers, agriculturalists, representatives of local authority, restaurant owners, construction workers, artists, teachers & academics teamed up to co-design the future of Tinos. The workshop was implemented according to the methodology of World Cafe by encouraging the participants to work in five teams, to think with heart & mind, to express freely, to fuse ideas & concepts and to interact in a friendly space. The process was successful as all the participants ended up with interesting ideas & solutions, revolving around the basic questions: How are we envisioning Tinos as a paradigm of sustainable development? Which are the best practices, already evident on the island? What's missing? Which is the contribution of each & everyone based on profession/profile towards sustainable & circular economy practices?

Based on these questions, each group chose one category between energy, water, food and employment in which explored viable scenarios around this category, while considering the environmental, social and economic impacts and the particular characteristics of the site. Moreover, questionnaires were distributed to record the needs of the participants related with the Information and Communication Technologies and the parameters that must be measured for monitoring and controlling the reclaimed water in Tinos Island. The feedback received helped to better implement the systems of demo sites HYDRO5 and HYDRO6. Specifically, the online monitoring system of HYDRO5 and HYDRO6 was influenced by the co-creation workshop of Tinos.

Figure 2.23 Photos of the co-creation workshop at Tinos

2.3.2 Soil analysis

HYDRO 5 agriculture demo site is based on a greenhouse; thus, soil of high quality (mixed with sand and compost) will be purchased and transformed to the site. In HYDRO 6 (Tinos Ecolodge), complete soil analysis was performed to all plots where different types of crops (vegetables, herbs, artichokes and grapes) will be cultivated (See section 6 for complete soil analysis report). Fertilization recommendations were also determined for each plot as shown in Tables 2.14 to 2.19:

Table 2.14 Soil analysis and fertilization recommendation for cultivation of vegetables at Tinos Ecolodge

Particle size:	Light, warm, dry soil, suffer from low nutrients that are washed away by rain, has reduced water and nutrient retention capacity It has good ventilation and drainage conditions are created for plant growth. The soil must be sufficiently irrigated and fertilized at frequent and small doses
pH :	pH is higher than recommended for cultivation of vegetables
	pH is high and may cause micronutrient (especially iron) and phosphorus deficiencies. Nitrogen should be applied in acid form. Advantageously, it is useful to apply foil sprays containing trace elements (especially Fe and Zn) and phosphorus.

Electrical Conductivity:	**Very low**	Possible appearance of deficiencies. Poor soil with low microbial activity			
Total Calcium Carbonate:	**Average**	There are no problems with cultivation			
Active Active Calcium Carbonate:		There are no problems with cultivation			
Organic matter:	**Very Low**	It is recommended to add, 10-15 t/ha of well decomposition animal manure or 800 – 1,000 kg/ha of compost, in winter or at least one month before sowing or planting. Reduce the nitrogen dose by 1.5 - 2 units per tonne of manure added			
C.E.C. (Cation Exchange Capacity):		***Sufficient Content***			
C/N ratio:		Intense biological activity, favorable conditions of decomposition of plant debris and release of inorganic nutrients.			
	Recommended fertilizing		**Recommended fertilizer**		
	Dose (Units)	**How to apply fertilizers**	**Type of fertilizer**	**Dose (kg /ha)**	
Nitrogen (N)	***Very Low content***		***Suggested dose of nitrogen:***	***16***	***Units***
	5	By deep placement prior to planting	Compound fertilizer 15-15-15	**333**	
	7	Placement with irrigation alternately with potassium nitrate	Ammonium nitrate 34,5-0-0	**203**	
	4	Placement with irrigation alternately with ammonium nitrate	Potassium nitrate 13-0-46	**308**	
Available Phosphorus (P)	***Average to High content***				

Available Potassium (K)	***Low content***			
	20	It is applied at the end of the winter with a depth of at least 10 cm.	Potassium sulphate (0-0-50)	**400**
Manganese (Mn)	***Low Content***			
	0.8 Units	It is applied by integration into the soil close to the planting line	Manganese Sulfate 36% granular	**25 kg/ha**
Cooper (Cu)	***Sufficient Content***			
	0.3 Units	It is applied by integration into the soil before sowing or planting (depth 0-20 cm).	Hydrate Copper Sulphate (CuSO4 5H2O) 25% Crystal (blue)	**12 kg/ha**
Boron (B)	***Low Content***			
	0.6 Units	It is applied by integration into the soil (10-15 cm) early in spring before plant growth begins. Avoid very premature application due to leaching	Borax 11,5%	**53 kg/ha**
Available Magnesium (Mg)	**Very high content sufficient for more than 4 years. Can cause K deficiency and in sensitive crops and Ca**			
Available Calcium (Ca)	***Low Content. It is recommended to add calcium***			
	It is proposed to improve the soil by adding calcium, CaCO3, CaO or Ca (OH) 2 compounds. Together with calcium, dolomite (Magnesium) is added in proportion (10% -25%). It is also recommended to re-test the pH every two years			
	It is applied by spreading and incorporating at a depth of 20 cm from autumn to the end of winter		Calcium carbonate (CaCO3)	**5,000.0 kg/ha**

Table 2.15 Soil analysis and fertilization recommendation for cultivation of forest trees at Tinos Ecolodge

Particle size:	Light, warm, dry soil, suffer from low nutrients that are washed away by rain, has reduced water and nutrient retention capacity It has good ventilation and drainage conditions are created for plant growth. The soil must be sufficiently irrigated and fertilized at frequent and small doses			
pH:	pH is suitable for cultivation of forest trees			
	Cation exchange capacity produces close to 100% of nutrients			
Electrical Conductivity:	**Very low**	Possible appearance of deficiencies. Poor soil with low microbial activity		
Total Calcium Carbonate:	**Average**	There are no problems with cultivation		
Active Calcium Carbonate:		There are no problems with cultivation		
Organic matter:	**Very High**	The soil is provided with an organic matter. No organic matter is required for 2-3 years. It is proposed to reduce the nitrogen dose by 5-6 units.		
C.E.C. (Cation Exchange Capacity):		Low price		
C/N ratio:		Slow degradation. Nitrogen is removed from the soil. No nitrogen is available for plants. Nitrogen fertilization is recommended		
	Recommendedd fertilizing		**Recommended fertilizer**	
	Dose (Units)	**How to apply fertilizers**	**Type of fertilizer**	**Dose (kg /ha)**
Nitrogen (N)	***Very Low content***		***Suggested dose of nitrogen:***	***Units***
Available Phosphorus (P)	***Very Low content***			
	10	It is applied at the end of the winter to early spring with a depth of at least 15-20 cm. Linear application	Triple superphosphate	**217**

<table>
<tr><td></td><td></td><td>during sowing facilitates the intake of the nutrient</td><td>(0-46-0)</td><td></td></tr>
<tr><td>Available Potassium (K)</td><td colspan="4">Sufficient content</td></tr>
<tr><td>Available Magnesium (Mg)</td><td colspan="4">Very high content sufficient for more than 4 years. Can cause K deficiency and in sensitive crops and Ca</td></tr>
<tr><td></td><td colspan="4"></td></tr>
<tr><td rowspan="3">Available Calcium (Ca)</td><td colspan="4">Low Content. It is recommended to add calcium</td></tr>
<tr><td colspan="4">It is proposed to improve the soil by adding calcium, CaCO3, CaO or Ca $(OH)_2$ compounds. Together with calcium, dolomite (Magnesium) is added in proportion (10% -25%). It is also recommended to re-test the pH every two years</td></tr>
<tr><td colspan="3">It is applied by spreading and incorporating at a depth of 20 cm from autumn to the end of winter</td><td>Calcium carbonate ($CaCO_3$)</td></tr>
<tr><td>Iron (Fe)</td><td colspan="4">Very High Content</td></tr>
<tr><td>Zinc (Zn)</td><td colspan="4">Sufficient Content</td></tr>
<tr><td>Manganese (Mn)</td><td colspan="4">Sufficient Content</td></tr>
<tr><td>Cooper (Cu)</td><td colspan="4">Sufficient Content</td></tr>
<tr><td>Boron (B)</td><td colspan="4">Very High Content</td></tr>
</table>

Table 2.16 Soil analysis and fertilization recommendation for cultivation of Grapes at Tinos Ecolodge

Particle size:	Light, warm, dry soil, suffer from low nutrients that are washed away by rain, has reduced water and nutrient retention capacity It has good ventilation and drainage conditions are created for plant growth. The soil must be sufficiently irrigated and fertilized at frequent and small doses				
pH:	pH is suitable for cultivation of grapes				
	Cation exchange capacity produces close to 100% of nutrients				
Electrical Conductivity:	**Very low**	Possible appearance of deficiencies. Poor soil with low microbial activity			
Total Calcium Carbonate:	**Average**	There are no problems with cultivation			
Active Calcium Carbonate:		There are no problems with cultivation			
Organic matter:	**Very High**	The soil is provided with an organic matter. No organic matter is required for 2-3 years. It is proposed to reduce the nitrogen dose by 5-6 units.			
C.E.C. (Cation Exchange Capacity):		Low price			
C/N ratio:		Slow degradation. Nitrogen is removed from the soil. No nitrogen is available for plants. Nitrogen fertilization is recommended			
	Recommendedd fertilizing		**Recommended fertilizer**		
	Dose (Units)	**How to apply fertilizers**	**Type of fertilizer**	**Dose (kg /ha)**	
Nitrogen (N)	***Very Low content***		***Suggested dose of nitrogen:***		***Units***
Available Phosphorus (P)	***Sufficient Content***				
	6	It is applied at the end of the winter to early spring with a depth of at least 15-20 cm. Linear application	Triple superphosphate	**130**	

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 776643

		during sowing facilitates the intake of the nutrient	(0-46-0)	
Available Potassium (K)	***Sufficient Content***			
Available Magnesium (Mg)	***Very high content sufficient for more than 4 years. Can cause K deficiency and in sensitive crops and Ca***			
Available Calcium (Ca)	***Low Content. It is recommended to add calcium***			
	It is proposed to improve the soil by adding calcium, $CaCO_3$, CaO or $Ca(OH)_2$ compounds. Together with calcium, dolomite (Magnesium) is added in proportion (10% -25%). It is also recommended to re-test the pH every two years			
	It is applied by spreading and incorporating at a depth of 20 cm from autumn to the end of winter		Calcium carbonate ($CaCO_3$)	**5,000.0 kg/ha**
Iron (Fe)	***Very High Content***			
Zinc (Zn)	***Sufficient Content***			
Manganese (Mn)	***Sufficient Content***			
Cooper (Cu)	***Low Content***			
	0.4 Units	It is applied by integration into the soil before sowing or planting (depth 0-20 cm).	Hydrate Copper Sulphate ($CuSO_4$ $5H_2O$) 25% Crystal	**16 kg/ha**
Boron (B)	***Low Content***			
	0.5 Units	It is applied by integration into the soil (10-15 cm) early in the spring before plant growth begins. Avoid very premature application due to leaching	Borax 11,5%	**44 kg/ha**

Table 2.17 Soil analysis and fertilization recommendation for cultivation of Artichokes at Tinos Ecolodge

Particle size:	Light, warm, dry soil, suffer from low nutrients that are washed away by rain, has reduced water and nutrient retention capacity It has good ventilation and drainage conditions are created for plant growth. The soil must be sufficiently irrigated and fertilized at frequent and small doses				
pH:	pH is suitable for cultivation of Artichokes				
	Cation exchange capacity produces close to 100% of nutrients				
Electrical Conductivity :	**Very low**	Possible appearance of deficiencies. Poor soil with low microbial activity			
Total Calcium Carbonate:	**Average**	There are no problems with cultivation			
Active Calcium Carbonate:		There are no problems with cultivation			
Organic matter:	**Very Low**	It is recommended to add, 10-15 t/ha of well decomposition animal manure or 800 – 1,000 kg per ha of compost, in winter or at least one month before sowing or planting. Reduce the nitrogen dose by 1.5 - 2 units per tonn of manure added			
C.E.C. (Cation Exchange Capacity):		Very low. Only few elements available. Possible Potassium and Magnesium deficiency			
C/N ratio:		Intense biological activity, favorable conditions of decomposition of plant debris and release of inorganic nutrients.			
	Recommended fertilizing		**Recommended fertilizer**		
	Dose (Units)	**How to apply fertilizers**	**Type of fertilizer**	**Dose (kg /ha)**	
Nitrogen (N)	***Low content***		***Suggested dose of nitrogen:***	***12***	***Units***
	4	By deep placement prior to planting	15-15-15	**267**	
	8	Placement with irrigation	34.5-0-0	**232**	

		alternately with potassium nitrate		
Available Phosphorus (P)	***Sufficient Content***			
	8	It is applied at the end of the winter to early spring with a depth of at least 15-20 cm. Linear application during sowing facilitates the intake of the nutrient	Triple superphosphate (0-46-0)	**174**
Available Potassium (K)	***Marginal Content***			
	15	It is applied at the end of the winter with a depth of at least 10 cm.	Potassium Sulphate (0-0-50)	**300**
Available Magnesium (Mg)	**Very Low content**			
	3.0 Units	It is applied to basic fertilizer. In sandy soils it is recommended to use it as a surface fertilizer	Magnesium sulphate granular MgO	**12 kg/ha**
Available Calcium (Ca)	***Low Content. It is recommended to add calcium***			
	It is proposed to improve the soil by adding calcium, CaCO3, CaO or Ca (OH) 2 compounds. Together with calcium, dolomite (Magnesium) is added in proportion (10% -25%). It is also recommended to re-test the pH every two years			
	It is applied by spreading and incorporating at a depth of 20 cm from autumn to the end of winter		Calcium carbonate (CaCO3)	**4,200.0 kg/ha**
Iron (Fe)	***Very High Content***			
Zinc (Zn)	***Sufficient Content***			
Manganese (Mn)	***Very Low Content***			
	1.0 Unit	It is applied by integration into the soil close to the planting line	Manganese sulphate 36% granular	**31 kg/ha**
Cooper (Cu)	***Low Content***			
	0.3 Units	It is applied by integration into the soil before sowing or planting (depth 0-20 cm).	Hydrate copper sulphate (CuSO4 5H2O) 25%	**12 kg/ha**

			Crystal	
Boron (B)	***Low Content***			
	0.6 Units	It is applied by integration into the soil (10-15 cm) early in the spring before plant growth begins. Avoid very premature application due to leaching	Borax 11,5%	**53 kg/ha**

Table 2.18 Soil analysis and fertilization recommendation for cultivation of Herbs at Tinos Ecolodge

Particle size:	Light, warm, dry soil, suffer from low nutrients that are washed away by rain, has reduced water and nutrient retention capacity It has good ventilation and drainage conditions are created for plant growth. The soil must be sufficiently irrigated and fertilized at frequent and small doses				
pH:	pH is suitable for cultivation of herbs				
	Cation exchange capacity produces close to 100% of nutrients				
Electrical Conductivity:	**Very low**	Possible appearance of deficiencies. Poor soil with low microbial activity			
Total Calcium Carbonate:	**Average**	There are no problems with cultivation			
Active Calcium Carbonate:		There are no problems with cultivation			
Organic matter:	**Very High**	The soil is provided with an organic matter. No organic matter is required for 2-3 years. It is proposed to reduce the nitrogen dose by 5-6 units.			
C.E.C. (Cation Exchange Capacity):		Very low. Only few elements available. Possible Potassium and Magnesium deficiency			
C/N ratio:		Intense biological activity, favorable conditions of decomposition of plant debris and release of inorganic nutrients.			
	Recommended fertilizing		**Recommended fertilizer**		
	Dose (Units)	**How to apply fertilizers**	**Type of fertilizer**	**Dose (kg /ha)**	
Nitrogen (N)	***Low content***		***Suggested dose of nitrogen:***	***7***	***Units***
	4	By deep placement prior to planting	20-20-20	**200**	
	3	Placement with irrigation alternately with potassium nitrate	34.5-0-0	**87**	

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 776643

Available Phosphorus (P)	***Low Content***			
	20	It is applied at the end of the winter to early spring with a depth of at least 15-20 cm. Linear application during sowing facilitates the intake of the nutrient	Triple superphosphate (0-46-0)	**435**
Available Potassium (K)	***Sufficient Content***			
	6	It is applied at the end of the winter with a depth of at least 10 cm.	Potassium sulphate (0-0-50)	**120**
Available Magnesium (Mg)	***Sufficient content***			
Available Calcium (Ca)	***Low Content. It is recommended to add calcium***			
	It is proposed to improve the soil by adding calcium, $CaCO_3$, CaO or $Ca(OH)_2$ compounds. Together with calcium, dolomite (Magnesium) is added in proportion (10% -25%). It is also recommended to re-test the pH every two years			
	It is applied by spreading and incorporating at a depth of 20 cm from autumn to the end of winter		Calcium carbonate ($CaCO_3$)	**5,000.0 kg/ha**
Iron (Fe)	***Very High Content***			
Zinc (Zn)	***Sufficient Content***			
Manganese (Mn)	***Sufficient Content***			
Cooper (Cu)	***Low Content***			
	0.4 Units	It is applied by integration into the soil before sowing or planting (depth 0-20 cm).	Hydrate copper sulphate ($CuSO_4 5H_2O$) 25% Crystal	**16 kg/ha**
Boron (B)	***Low Content***			
	0.6 Units	It is applied by integration into the soil (10-15 cm) early in the spring before plant growth begins. Avoid very premature application due to leaching	Borax 11,5%	**53 kg/ha**

Table 2.19 Soil analysis and fertilization recommendation for cultivation of Citrus at Tinos Ecolodge

<table>
<tr><td>Particle size:</td><td colspan="5">Light, warm, dry soil, suffer from low nutrients that are washed away by rain, has reduced water and nutrient retention capacity

It has good ventilation and drainage conditions are created for plant growth. The soil must be sufficiently irrigated and fertilized at frequent and small doses</td></tr>
<tr><td rowspan="2">pH:</td><td colspan="5">pH is suitable for cultivation of citrus</td></tr>
<tr><td colspan="5">pH is high and may cause micronutrient (especially iron) and phosphorus deficiencies. Nitrogen should be applied in acid form. Advantageously, it is useful to apply foil sprays containing trace elements (especially Fe and Zn) and phosphorus</td></tr>
<tr><td>Electrical Conductivity :</td><td>Low</td><td colspan="4">There are no problems with cultivation</td></tr>
<tr><td>Total Calcium Carbonate:</td><td>Sufficient Conten</td><td colspan="4">The presence of CaCO3 increases the possibilityof problems with iron and zinc. The soil is resistant to acid fertilizers.</td></tr>
<tr><td>Active Calcium Carbonate:</td><td></td><td colspan="4">There are no problems with cultivation</td></tr>
<tr><td>Organic matter:</td><td>Very High</td><td colspan="4">The soil is provided with an organic matter. No organic matter is required for 3-4 years. It is proposed to reduce the nitrogen dose by 5-6 units.</td></tr>
<tr><td colspan="2">C.E.C. (Cation Exchange Capacity):</td><td colspan="4">Average prize</td></tr>
<tr><td colspan="2">C/N ratio:</td><td colspan="4">Slow degradation. Nitrogen is removed from the soil. No nitrogen is available for plants. Nitrogen fertilization is recommended.</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td></td><td colspan="2">Recommended fertilizing</td><td colspan="3">Recommended fertilizer</td></tr>
<tr><td></td><td>Dose (Units)</td><td>How to apply fertilizers</td><td>Type of fertilizer</td><td colspan="2">Dose (kg /ha)</td></tr>
<tr><td>Nitrogen (N)</td><td colspan="2">Low content</td><td>Suggested dose of nitrogen:</td><td></td><td>Units</td></tr>
<tr><td>Available</td><td colspan="5">Very High Content</td></tr>
</table>

Phosphorus (P)				
Available Potassium (K)	***Marginal Content***			
	12	It is applied at the end of the winter with a depth of at least 10 cm.	Potassium sulphate (0-0-50)	**240**
Available Magnesium (Mg)	***Sufficient Content***			
Available Calcium (Ca)	***Average Content***			
Iron (Fe)	***Low Content***			
	0.6 Units	It is applied to the soil at the end of winter with incorporation. In heavy soils it is good to apply a little earlier. The recommended dose should be distributed so as to benefit the entire root system of the plants. Application to foliage is recommended only in exceptional cases	Sequestrene 138 (Fe-EDDHA NaFe 6%)	**109 kg/ha**
Zinc (Zn)	***Sufficient Content***			
Manganese (Mn)	***Low Content***			
	0.8 Units	It is applied by integration into the soil close to the planting line	Manganese sulfate 36% granular	**25 kg/ha**
Cooper (Cu)	***Sufficient Content***			
	0.3 Units	It is applied by integration into the soil before sowing or planting (depth 0-20 cm).	Hydrate copper sulphate ($CuSO_4$ $5H_2O$) 25% Crystal	**12 kg/ha**
Boron (B)	***High Content***			

2.3.3 Irrigation

Two approaches have been used to calculate the expected water demands of the Greenhouse (GH) for tropical fruits on Tinos Island (HYDRO 5) (see Figure 2.24). The first approach is by area and the comparison to rainfall in the humid tropics or common irrigation practices during dry periods in the tropics. The other approach is by using the estimated water demand by plant and species.

The first approach is rather easy. The net planted area in the GH is 132 m^2. In the tropics about 1,000 mm of rainfall would be the minimum for acceptable plant growth for most fruits. This works out to about 3 mm per day, meaning 3 litres of water per m^2 per day. So, this results in an expected demand of 375 litres of water per day for the whole GH.

The plants however will be irrigated by drip irrigation systems, which allow a very targeted and economic water supply to the plants. Soil surface evaporation and losses would be minimized. So, doing a plant-by-plant estimation might give a different, lower result. These estimations have been made for summer, winter and the intermediate periods. The calculations are displayed in **Figure *2.24*** and numbers summarized in Table 2.20. The calculations also rely on the planting plans of different plots in the greenhouse and plant densities, as laid out in Table 2.21 to Table 2.29.

As shown in Table 2.20, peak water consumption is expected during the summer months. This considers the fact that summer days in Tinos are longer than the days in the tropics, which may lead to increased water needs of the plants. This peak at 450 l per day is higher than the average demand derived from the rainfall comparison in the tropics. For the intermediate periods and winter the water demand is expected to be much lower, 270 l/day and 160 l/day respectively.

However, there are some considerations that could impact the real consumption:

- no shading has been implemented for the GH for the summer months. Plants will have to prevent overheating by their own devices, so this may increase the water demand to avoid heat damage. On the other hand, the constant and well-known winds of Tinos Island should prevent the creation of stationary heat islands. But a strong air exchange has also a drying effect, which increases evapotranspiration.
- as plants grow and during the fruit production phase, their water demands increase. However, with denser foliage the self-shading effect also reduces overheating and thus less transpiration is necessary to cool off the plants. Young plants will need less water, bigger older plants considerably more.

1,3,4,6,7,9 = 8*2 = 16 (*6) = 96 m2
2,5,8 = 8*1.5 = 12 (*3) = 36 m2

Total production area = 132m2

Total greenhouse area = 194 m2

10,11 = 1*24 = 24 (*2) = 48 m2
12,13 = 0.25*24 = 6 (*2) = 12 m2
14 = 0.25*8 = 2 (*1) = 2 m2

Total service area = 62 m2

SEG 4 X 7 m = 28 m2

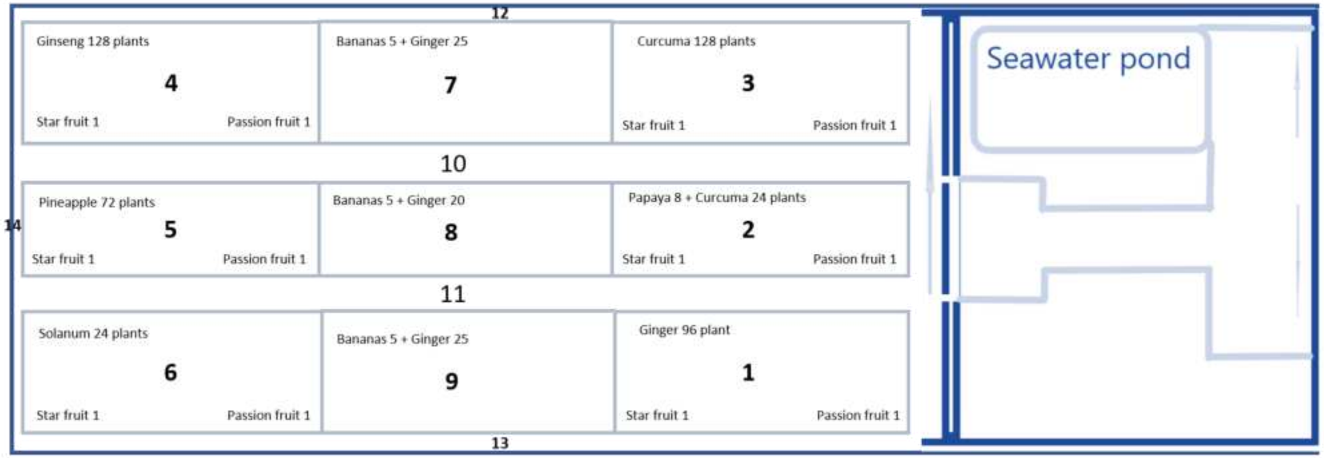

Figure 2.24 Tropical fruit production greenhouse and seawater greenhouse (SEG) layout

Table 2.20 Water demand estimation for tropical plants during summer and winter seasons

Spring/Autumn		Ginger	Papaya	Curcuma	Korean Ginseng	Pineapple	Solanum muric.	Banana	Passiflora	Papaya	Starfruit	
Water/d	per plant (l)	0.17	0.6	0.17	0.18	0.5	0.45	1.25	0.45	0.6	1.2	Water /d tot.
		23.97	6.6	26.18	14.04	107.5	18.45	51.25	6.75	1.8	15.6	272
Summer		**Ginger**	**Papaya**	**Curcuma**	**Korean Ginseng**	**Pineapple**	**Solanum muric.**	**Banana**	**Passiflora**	**Papaya**	**Starfruit**	
Water/d	per plant (l)	0.2822	0.996	0.2822	0.2988	0.83	0.747	2.075	0.747	0.996	1.992	Water /d tot.
		39.790	10.956	43.4588	23.3064	178.45	30.627	85.075	11.205	2.988	25.896	452
Winter		**Ginger**	**Papaya**	**Curcuma**	**Korean Ginseng**	**Pineapple**	**Solanum muric.**	**Banana**	**Passiflora**	**Papaya**	**Starfruit**	
Water/d	per plant (l)	0.102	0.36	0.102	0.108	0.3	0.27	0.75	0.27	0.36	0.72	Water /d tot.
		14.382	3.96	15.708	8.424	64.5	11.07	30.75	4.05	1.08	9.36	163

Table 2.21 Total plants per parcel according to planting plan

Parcel	area m^2	Ginger	Papaya	Curcuma	Korean Ginseng	Pineapple	Solanum muric.	Banana	Passiflora	Papaya	Starfruit
1	16	96				74			2	1	
2	12	39	9						2		
3	16			122					2		1
4	16				78				9		9
5	12					96				1	1
6	16						38			1	2
7	30			26		39		39			
SEG	8	6	2	6		6	3	2			
Total Plants GH		**141**	**11**	**154**	**78**	**215**	**41**	**41**	**15**	**3**	**13**

Table 2.22 Tinos Fruit Production GH planting plan plot 1

Irrigation Line	***Dripper position**																									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
1	Fl	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA
2			Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi
3	Pp		PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA
4			Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi	Gi Gi
5	Fl	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA

Pineapple =	**PA**	**Total plants**	**74**	Plant density aprox	25 x 30
Ginger =	**Gi**	**Total plants**	**96**	Plant density aprox	15 x 30
Passiflora =	**Fl**	**Total plants**	**2**	Plant density aprox	50 x 105
Papaya =	**Pp**	**Total plants**	**1**	Plant density aprox	80 x 150

***Dripper irrigation hoses required:** **40 m**

Table 2.23 Tinos Fruit Production GH planting plan plot 2

Irrigation Line	***Dripper position**																									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
1	Gi		Gi	Gi	Gi	Gi	Gi		Gi	Gi	Gi	Gi	Gi		Gi	Gi	Gi	Gi	Gi		Gi	Gi	Gi	Gi	Gi	
2		Pp						Pp						Pp						Pp						Pp
3					Pp						Pp						Pp						Pp			
4	Fl		Gi	Gi		Gi	Gi	Gi	Gi	Gi		Gi	Gi	Gi	Gi	Gi		Gi	Gi	Gi	Gi	Gi		Gi		Fl

Ginger =	**Gi**	**Total plants**	**39**	Plant density aprox	50 x 30
Passiflora =	**Fl**	**Total plants**	**2**	Plant density aprox	50 x 105
Papaya =	**Pp**	**Total plants**	**9**	Plant density aprox	80 x 150
***Dripper irrigation hoses required:**					32 m

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Table 2.24 Tinos Fruit Production GH planting plan plot 3

Irrigation Line	*Dripper position																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	Fl		Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu
2		Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu
3	SF		Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu
4		Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu
5	Fl		Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu

Curcuma =	**Gi**	**Total plants**	**122**	Plant density aprox	25 x 30
Passiflora =	**Fl**	**Total plants**	**2**	Plant density aprox	50 x 105
Starfruit =	**Pp**	**Total plants**	**1**	Plant density aprox	80 x 150
***Dripper irrigation hoses required:**					40 m

Table 2.25 Tinos Fruit Production GH planting plan plot 4

Irrigation Line	*Dripper position																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG
2		FL			FL			FL			FL			FL			FL			FL			FL			FL
3	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG
4	SF			SF			SF			SF			SF			SF			SF			SF			SF	
5	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG	KG

Korean Ginseng =	**KG**	**Total plants**	**78**	Plant density aprox	15 x 20
Passiflora =	**Fl**	**Total plants**	**9**	Plant density aprox	50 x 105
Starfruit =	**SF**	**Total plants**	**9**	Plant density aprox	80 x 150

***Dripper irrigation hoses required:** 40 m

Note: 2 extra irrigation lines in this plot due to dense planting of KG

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Table 2.26 Tinos Fruit Production GH planting plan plot 5

Irrigation Line	***Dripper position**																									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
1		PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	
2	Pp		PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA		SF
3		PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	
4	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA

Pineapple =	**PA**	**Total plants**	**96**	Plant density aprox	25 x 30
Papaya =	**Pp**	**Total plants**	**1**	Plant density aprox	50 x 105
Starfruit =	**SF**	**Total plants**	**1**	Plant density aprox	80 x 150

***Dripper irrigation hoses required:** 40 m

Note: 2 extra irrigation lines in this plot due to dense planting of KG

Table 2.27 Tinos Fruit Production GH planting plan plot 6

Irrigation Line	*Dripper position																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1		SM		SM		SM		SM		SM		SM		SM		SM		SM		SM		SM		SM		SF
2	Pp		SM		SM		SM		SM		SM		SM		SM		SM		SM		SM		SM		SM	
3		SM		SM		SM		SM		SM		SM		SM		SM		SM		SM		SM		SM		SF

Solanum muricatum =	**SM**	**Total plants**	**78**	Plant density aprox	60 x 30
Papaya =	**Pp**	**Total plants**	**1**	Plant density aprox	80 x 150
Starfruit =	**SF**	**Total plants**	**2**	Plant density aprox	80 x 150
***Dripper irrigation hoses required:**					24 m

Table 2.28 Tinos Fruit Production GH planting plan plot 7

Irrigation Line	*Dripper position																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	PA		PA		PA		PA		PA		PA		PA		PA		PA		PA		PA		PA		PA	
2		Ba		Ba		Ba		Ba		Ba		Ba		Ba		Ba		Ba		Ba		Ba		Ba		Ba
3	Cu		Cu		Cu		Cu		Cu		Cu		Cu		Cu		Cu		Cu		Cu		Cu		Cu	
4		Ba		Ba		Ba		Ba		Ba		Ba		Ba		Ba		Ba		Ba		Ba		Ba		Ba
5	Cu		Cu		Cu		Cu		Cu		Cu		Cu		Cu		Cu		Cu		Cu		Cu		Cu	
6		PA		PA		PA		PA		PA		PA		PA		PA		PA		PA		PA		PA		PA
7	PA		PA		PA		PA		PA		PA		PA		PA		PA		PA		PA		PA		PA	
8		Ba		Ba		Ba		Ba		Ba		Ba		Ba		Ba		Ba		Ba		Ba		Ba		Ba

Banana =	**Ba**	**Total plants**	**39**	Plant density aprox	90 x 70
Curcuma =	**Cu**	**Total plants**	**26**	Plant density aprox	80 x 150
Pineapple =	**PA**	**Total plants**	**39**	Plant density aprox	45 x 30

***Dripper irrigation hoses required:** 48 m
Note: 9 irrigation lines at about 45 cm distance

Table 2.29 Tinos Fruit Production GH planting plan SEG

Irrigation Line	*Dripper position												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1	Gi	PA	Cu	PA	Cu	PA	Cu	PA	Cu	PA	Cu	PA	Gi
2	Ba		Gi		Ba		Gi		Pp		Gi		Pp
3	Cu		SM				SM				SM		Gi

Pineapple =	**PA**	**Total plants**	**6**
Ginger =	**Gi**	**Total plants**	**6**
Papaya =	**Pp**	**Total plants**	**2**
Banana	**Ba**	**Total plants**	**2**
Curcuma =	**Cu**	**Total plants**	**6**
Solanum muricatum =	**SM**	**Total plants**	**3**
***Dripper irrigation hoses required:**			12 m

HYDRO 6

There are seven plots in Tinos Ecolodge with a variety of plants (grapes, artichokes, lavender, thyme, oregano, sage, rosemary, caper, prickly pear, veggie garden). The water needs were calculated following the methodology used for HYDRO3 and HYDRO4, described above (section 2.2.3). Thus, the empirical method of Blaney - Criddle is applied, importing the meteorological data (average monthly temperature, monthly rainfall) for Tinos Island. Using also the plant factor K (Table 2.7), the Blaney - Criddle evapotranspiration rate was calculated for each kind of plant in Tinos Ecolodge followed by the net and total water needs (Table 2.30 - Table 2.33). The deficit irrigation described in section 2.2.3 is used for all the cultivations in HYDRO6 except the veggie gardens. The duration of the irrigation period is from April to mid-August for all the plants, but the veggie gardens (Plot N and Greenhouse) that are irrigated from April to November. Plot A is a vineyard that now is only used to produce a Greek distillate (raki), so it is not irrigated. In plot B and C artichokes are cultivated; in plot D-E and M mainly herbs with some prickly pears in the sides as plot N and the Greenhouse are veggie gardens.

Table 2.30: Calculation of crop needs in water according to the Blaney - Griddle method for Plot B+ C: Artichokes, K=0.65

Month	Average Monthly Temperature	Percentage of hours of the Day	$f = \frac{(T+18)}{22} * p$	Average monthly rainfall (10years) (mm)		Monthly Evapotranspiration (mm)	Net Water Consumption (mm)
	T (°C)	p	f	*Actual R*	Useful R'	U = K*f	N = U-R'
January	11.9	6.9	93.4	78.7	56.86	60.7	3.83
February	12.8	6.8	95.1	63.9	43.91	61.8	17.88
March	13.8	8.3	120.6	35.4	18.98	78.4	59.38
April	16.5	8.9	139.6	14.7	0.86	90.7	89.86
May	20.3	9.9	172.7	7.5	-5.44	112.3	117.69
June	24.3	10.0	191.3	5.2	-7.45	124.4	131.80
July	26.7	10.1	205.2	0.0	-12.00	133.4	145.39
August	26.5	9.5	191.6	0.1	-11.91	124.5	136.42
September	24.0	8.4	160.0	10.4	-2.90	104.0	106.89
October	19.7	7.8	133.7	14.4	0.60	86.9	86.28
November	16.7	6.8	107.6	34.5	18.19	69.9	51.73
December	13.3	6.7	94.8	85.4	62.73	61.6	-1.14
Total				350.20	162.43	1108.44	946.02

Months												TOTAL
J	F	M	A	M	J	J	A	S	O	N	D	

Percentage of days of the month

0	0	0	0.3	0.3	0.3	0.3	0	0	0	0	0	

Net Water Consumption (mm)

3.83	17.88	59.38	89.86	117.69	131.80	145.39	136.42	106.89	86.28	51.73	-1.14	946.02

Net Water Requirements for Crop Irrigation (According to the Deficit Irrigation Method) (m3/0.1 ha)

0.00	0.00	0.00	13.48	21.18	35.59	43.62	0.00	0.00	0.00	0.00	0.00	113.87

Total water requirements, including losses of transportation, distribution, filtration and evaporation in the field, and illegal water provision along the route in the irrigation network (m3/0.1 ha)

0.00	0.00	0.00	13.50	21.22	35.64	43.68	0.00	0.00	0.00	0.00	0.00	114.04

Total annual water needs for the irrigation area (m^3/0.027 ha)	**30.79**

Table 2.31: Calculation of crop needs in water according to the Blaney - Griddle method for Plot D+E+M, Crop: herbs, K=0.55.

Month	Average Monthly Temperature	Percentage of hours of the Day	$f = \frac{(T+18)}{2.2} * p$	Average monthly rainfall (10years) (mm)		Monthly Evapotranspiration (mm)	Net Water Consumption (mm)
	T (°C)	p	f	*Actual R*	Useful R'	U = K*f	N = U-R'
January	11.9	6.9	93.4	78.7	56.86	51.4	-5.51
February	12.8	6.8	95.1	63.9	43.91	52.3	8.37
March	13.8	8.3	120.6	35.4	18.98	66.3	47.33
April	16.5	8.9	139.6	14.7	0.86	76.8	75.90
May	20.3	9.9	172.7	7.5	-5.44	95.0	100.42
June	24.3	10.0	191.3	5.2	-7.45	105.2	112.67
July	26.7	10.1	205.2	0.0	-12.00	112.9	124.87
August	26.5	9.5	191.6	0.1	-11.91	105.4	117.27
September	24.0	8.4	160.0	10.4	-2.90	88.0	90.89
October	19.7	7.8	133.7	14.4	0.60	73.5	72.92
November	16.7	6.8	107.6	34.5	18.19	59.2	40.98
December	13.3	6.7	94.8	85.4	62.73	52.1	-10.61
Total				350.20	162.43	937.91	775.49

Months												TOTAL
J	F	M	A	M	J	J	A	S	O	N	D	
Percentage of days of the month												
0.00	0.00	0.00	0.11	0.11	0.08	0.00	0.08	0.00	0.00	0.00	0.00	

Net Water Consumption (mm)

-5.51	8.37	47.33	75.90	100.42	112.67	124.87	117.27	90.89	72.92	40.98	-10.61	775.49

Net Water Requirements for Crop Irrigation (According to the Deficit Irrigation Method) (m^3/0.1 ha)

0.00	0.00	0.00	4.17	6.63	7.61	0.00	8.79	0.00	0.00	0.00	0.00	27.20

Total water requirements, including losses of transportation, distribution, filtration and evaporation in the field, and illegal water provision along the route in the irrigation network (m^3/0.1 ha)

0.00	0.00	0.00	4.18	6.64	7.62	0.00	8.81	0.00	0.00	0.00	0.00	27.24

Total annual water needs for the irrigation area (m^3/0.0279 ha)	**7.60**

Table 2.32: Calculation of crop needs in water according to the Blaney - Griddle method for Plot M: Pickly pear, K=0.65

Month	Average Monthly Temperature	Percentage of hours of the Day	$f = \frac{(T+18)}{2.2} * p$	Average monthly rainfall (10years) (mm)		Monthly Evapotranspiration (mm)	Net Water Consumption (mm)
	T (°C)	p	f	*Actual R*	Useful R'	U = K*f	N = U-R'
January	11.9	6.9	93.4	**78.7**	**56.86**	**60.7**	**3.83**
February	12.8	6.8	95.1	**63.9**	**43.91**	**61.8**	**17.88**
March	13.8	8.3	120.6	**35.4**	**18.98**	**78.4**	**59.38**
April	16.5	8.9	139.6	**14.7**	**0.86**	**90.7**	**89.86**
May	20.3	9.9	172.7	**7.5**	**-5.44**	**112.3**	**117.69**
June	24.3	10.0	191.3	**5.2**	**-7.45**	**124.4**	**131.80**
July	26.7	10.1	205.2	**0.0**	**-12.00**	**133.4**	**145.39**
August	26.5	9.5	191.6	**0.1**	**-11.91**	**124.5**	**136.42**
September	24.0	8.4	160.0	**10.4**	**-2.90**	**104.0**	**106.89**
October	19.7	7.8	133.7	**14.4**	**0.60**	**86.9**	**86.28**
November	16.7	6.8	107.6	**34.5**	**18.19**	**69.9**	**51.73**
December	13.3	6.7	94.8	**85.4**	**62.73**	**61.6**	**-1.14**
Total				**350.20**	**162.43**	**110.44**	**946.02**

Months												
J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TOTAL**
Percentage of days of the month												
0.00	**0.00**	**0.08**	**0.11**	**0.15**	**0.20**	**0.20**	**0.20**	**0.10**	**0.00**	**0.00**	**0.00**	
Net Water Consumption (mm)												

3.83	17.88	59.38	89.86	117.69	131.80	145.39	136.42	106.89	86.28	51.73	-1.14	946.02

Net Water Requirements for Crop Irrigation (According to the Deficit Irrigation Method) (m^3/0.1 ha)

0.00	0.00	2.38	4.94	10.59	23.72	29.08	27.28	10.69	0.00	0.00	0.00	108.68

Total water requirements, including losses of transportation, distribution, filtration and evaporation in the field, and illegal water provision along the route in the irrigation network (m^3/0.1 ha)

0.00	0.00	2.38	4.95	10.61	23.76	29.12	27.33	10.70	0.00	0.00	0.00	108.85

Total annual water needs for the irrigation area (m^3/0.0072 ha)	**7.84**

Table 2.33: Calculation of crop needs in water according to the Blaney - Griddle method for plot N and the Greenhouse (veggie gardens, K= 0.95)

Month	Average Monthly Temperature	Percentage of hours of the Day	$f=\frac{(T+18)}{22}*p$	Average monthly rainfall (10 years) (mm)		Monthly Evapotranspiration (mm)	Net Water Consumption (mm)
	T (°C)	p	f	*Actual R*	Useful R'	U = K*f	N = U-R'
January	11.9	6.9	93.4	78.7	56.86	88.7	31.84
February	12.8	6.8	95.1	63.9	43.91	90.3	46.39
March	13.8	8.3	120.6	35.4	18.98	114.5	95.55
April	16.5	8.9	139.6	14.7	0.86	132.6	131.73
May	20.3	9.9	172.7	7.5	-5.44	164.1	169.50
June	24.3	10.0	191.3	5.2	-7.45	181.7	189.20
July	26.7	10.1	205.2	0.0	-12.00	195.0	206.95
August	26.5	9.5	191.6	0.1	-11.91	182.0	193.89
September	24.0	8.4	160.0	10.4	-2.90	152.0	154.88
October	19.7	7.8	133.7	14.4	0.60	127.0	126.38
November	16.7	6.8	107.6	34.5	18.19	102.2	84.00
December	13.3	6.7	94.8	85.4	62.73	90.0	27.29
Total				350.20	162.43	1602.03	1457.60

Months												TOTAL
J	F	M	A	M	J	J	A	S	O	N	D	
Percentage of days of the month												
0.00	0.00	0.80	0.80	0.80	0.80	1.00	1.00	0.80	0.50	0.50	0.00	

Net Water Consumption (mm)

31.84	46.39	95.55	131.73	169.50	189.20	206.95	193.89	154.88	126.38	84.00	27.29	1,457.60

Net Water Requirements for Crop Irrigation (m^3/0.1 ha)

0.00	0.00	38.22	52.69	81.36	136.22	206.95	193.89	123.91	37.91	21.00	0.00	892.15

Total water requirements, including losses of transportation, distribution, filtration and evaporation in the field, and illegal water provision along the route in the irrigation network (m^3/0.1 ha)

0.00	0.00	38.28	52.77	81.48	136.43	207.26	194.18	124.09	37.97	21.03	0.00	893.49

Total annual water needs for the irrigation area (m^3/0.0215 ha)	**245.71**

3. DESCRIPTION OF PLANTS

3.1 Edible Trees

3.1.1 Castanea sativa (chestnut)

Part I: General aspects

Classification:
Latin name: *Castanea sativa*
Belongs to Fagaceae family, commonly known as chestnut, sweet chestnut, Spanish chestnut, Portuguese chestnut, and marron.

Figure 3.1 The general morphology of the chestnut tree and its nuts

Origin and distribution:

Many studies were conducted to determine the origin of the chestnut (see also Figure 3.1). Some of these studies use different sources of information such as pollen studies, archaeology, history and literature while others use anthropological, macrofossils and radiocarbon dated pollen records. Results showed that there are about seven regions distributed mainly in Italy and Greece suggested being the origin of chestnut. In addition, the human cultures (Romans Empire) help the distribution and expand of the chestnut from these regions to many other regions (Conedera et al., 2004; Lauteri et al., 2004 and Kosňovská, 2013).

The chestnut is distributed at many sites from southern Europe (Iberian Peninsula, Italy, Balkans, Mediterranean Islands) and North Africa (Morocco), North-Western Europe (England, Belgium) and Western Asia (Northeast Turkey, Armenia, Georgia, Azerbaijan, Syria), with an altitudinal range between 200 and 1,800 m, depending on the latitude and site aspects (Avanzato, 2009).

Production levels:

The production of European chestnut is about 151,903 tonnes all over Europe continent mainly at Turkey, Italy, Greece, Portugal, and Spain. The yield average was 1,325 t/ha (FAOSTAT, 2017). Many trees are found in South Africa growing in the cool climatic regions where they produce high amounts of the edible chestnuts.

Description of the plant:

The *Castanea sativa* plant is a large deciduous tree, which forms rounded canopy with high density of serrated leaves. The leaves are simple, ovate or lanceolate, sharply pointed, which are 10 – 30 cm long and 4–10 cm wide. Chestnuts are monoecious plants that produce male and female that is separated from each other on the same plant. The flowers are not self-compatible, so two trees are required for pollination. Chestnuts are mainly wind pollinated and after fertilization nuts form inside a spiny burr. Sweet chestnut trees grow up to 30 meters tall and can live for centuries in adequate conditions (Wilkinson, 2005).

Climatic requirements:

The trees produce the best yield when subjected to chill temperatures during the dormant period. Chestnuts trees tolerate sever cold climates; but the chilling requirements are not high as most other deciduous nut trees (Wilkinson, 2005). Temperature between 8°C and 15°C is the optimal average, while in January the temperature must not be below -1°C. On the other hand, the growth of the trees is affected by humidity. The plants are susceptible to root-rot and nut-rot, which are more severe in humid weather. Also when the weather is foggy or rainy during the growing season and nut fall, the nuts may be infected especially by nut rot, which cause critical crop loss (Wilkinson, 2005).

Soil requirements:

It does not prefer shallow or heavy soils with impermeable sub-soils. The most favorable soil for these trees is the deep sandy loam. Chestnuts can grow well in acidic soils, but the preferred pH range is between 5.5 and 6.5, also chestnuts do not tolerate alkaline soils (Wilkinson, 2005).

Part II: Cultivation practices

Propagation:

Seeds can be used for propagation of the chestnut plants (Sheat, 1948). The main vegetative propagation method for the chestnut plants is Grafting. The most popular method is shield or T budding that is done during spring. Rootstocks for grafting is grown from seed, some cultivars are used as root stocks, which show resistance to Phytophthora root-rot such as Menzies has been the favored rootstock (Ridley, 1999; Wilkinson, 2005).

Soil preparation:

Soil tillage is important to maintain level ground, relatively smooth for orchard work and harvesting. In order to improve the soil properties and enhance the growth of plants, organic matter must be added to the soil especially for poor soils.

Planting:

Castanea sativa plants can be cultivated for many purposes with different cultivation systems. Coppicing is the system for wood extraction, while Selve system is grafted trees for fruit production and the third one for wood and fruit production is the high forest system. It is recommended that the plants are cultivated with planting space 12 m * 12 m, also it can be cultivated at higher densities at the field (Fitzsimmons, 2006).

Fertilization:

In order to calculate the nutrient quantities that the plants need, soil and leaf analysis are performed. Weir and Cresswell (1993) mentioned the desirable elements range that should be in the leaf sample analysis in the mid-summer. Nitrogen ranges from 2.4 to 2.9 %, phosphorus 0.14 to 0.3 %, potassium 0.8 to 1.6 %, sulphur 0.15 to 0.25 %, calcium 0.6 to 1.4 % and magnesium 0.25 to 0.7 %. There is limited information on mineral fertilization of chestnut trees (Portela et al., 2007). In the past, only farm manure as organic fertilization was applied to chestnut trees that were not fertilized with chemical fertilizers.

Irrigation:

Chestnut trees are moderate dry tolerant, so the drought stress reduces the growth, yield and nut size. The trend today is for irrigation to ensure good nut size. Ensuring adequate soil moisture during nut development from midsummer to harvest is critical to nut size and quality. Precipitation less than 700 mm needs to be completed by irrigation with drip irrigation. During summer and early autumn, it is reccomened to irrigate the young trees until a strong root growth is formed (Wilkinson, 2005).

Disease control:

One of the many diseases that threat the chestnut industry is chestnut blight (Cryphonectria parasitica). It is a fungus, which enters through wounds on susceptible trees. At first the symptom of the infection is a small area with orange brownish colour on the tree bark and then a sunken canker is formed as the mycelia spread under the bark. The hyphae produce toxic compounds mainly oxalic acid, which decreases the pH till it reaches toxicity to plant cell (Wilkinson, 2005). Chestnut blight can be managed by chemical control and sanitation practices, however this is only feasible on a small scale, such as in an orchard. Sanitation practices like pruning of infected trees and branches can help in eliminating sources of infection and limit the spread of the pathogen. In addition, the disease can be controlled by using effective fungicides, which contain copper oxychloride and carbendazim (Berg, 2003; Conolly, 2007). Moreover, root and crown rot (Phytophthora cambivora and P. cinnamomi), commonly known as ink disease in Europe or crown root canker in America. It is a soil-borne fungus that attacks the roots, and the roots release a sap that turns black through oxidation of the tannins and the root system gradually dies. There are many ways to control the disease, such as injecting phosphorous acid into the trunk, spraying phosphorous acid on foliar, applying a suitable fungicide to the soil, and foliar spraying (Wilkinson, 2005).

Other cultivation practices:

Seeds must be stratified at 2-3°C before planting, so germination can start after 30–40 days. After a year, the young trees are being transplanted.

Concerning pruning, chestnut trees are not pruned regularly, but in recent years pruning has become an annual routine in order to increase nut size. Also, the tree training is important for trees, the pyramid and central leader are the suitable types of training for the chestnut trees (Wilkinson, 2005).

Harvesting:

Chestnuts are harvested by hand on a commercial scale and rubber or leather gloves are used to protect hands from the spines on the burrs (Wilkinson, 2005). The second method is by hand, but with nets that are less time-consuming and protects the fruits from injuries. The fruits can be also collected with a machine that works similarly to a vacuum cleaner. This is time-saving and economical, but it is possible that some fruits get injured, and a big initial investment is needed. Furthermore, a visual sorting is not possible.

Part III: Postharvest handling

Concerning postharvest handling of chestnuts, nuts are placed straight into the cool-room, or the sub-standard nuts were removed before placing them in the cool-room. The chestnuts are containerized in fruit bins at harvest but a bin full of chestnuts takes some time to cool. Accordingly, some growers ventilate the bin of nuts with slotted pipes to assist cooling. Otherwise, the bins of freshly harvested nuts are dipped into chilled water as a precooling process. Before market the cooled chestnuts are graded. The chestnut grading line consists of a trash remover to remove any leaf, burr or other debris, a water bath to remove the blank floating nuts, and an inspection line to remove substandard nuts. At this point the nuts can be returned to the cool room or conveyed to a size grader. Nuts are graded according to the number of nuts in a particular weight or nuts are size graded by falling through holes that range from 25 mm to 41+ mm diameter. The nuts are packed into 5 or 10 kg bags and stored in cool rooms with humidity greater than 90% and the temperature at 0°C (Wilkinson, 2005).

The treatment before storage is water curing, a process in which the sweet chestnuts are immersed in water for nine days (Botondi, 2009). The aim of this treatment is to limit the main storage problems threatening the sweet chestnut, such as fungi development and the presence of insect worms. In addition, hot water treatment is commercially used as an alternative to water curing. After water treatment, the sweet chestnuts are stored in a controlled environment with high carbon dioxide concentrations. In contrast to a cold storage system, where the fruits are stored at low temperatures in untreated air, the controlled environment method avoids flesh hardening which negatively impacts the process ability of the product (Botondi, 2009).

Correia et al. (2009) reported that the shelf life of chestnuts is very limited owing to large proportion of moisture and sugar content, pericarp characteristics and enzyme activity. So, chestnuts are frozen, cold stored, or dried to extend their storage period.

Part IV: Utilization:

The leaves are used to make a medicinal tea. European chestnut is used for breathing problems including bronchitis and whooping cough. Other uses include treatment of disorders affecting the legs and circulation, fever, infection, swelling, kidney disorders, muscle pain, a connective tissue disorder called sclerosis, and swelling of the lymph nodes due to tuberculosis infection. European chestnut is also used as a gargle for sore throat. Moreover, it is often used directly on the skin to treat wounds (Saleh, 2003; Web MD website). The nuts are an important commercial crop in southern Europe, where nuts are used by confectioners, eaten roasted and ground to make flour. Moreover, the wood of the tree is durable and is used to make furniture, barrels, fencing and roof beams.

3.1.2 Citrus aurantifolia (key lime)

Part I: General aspects

Classification:

Latin name: *Citrus aurantifolia* belongs to Rutaceae family

Known commonly as key lime

Figure 3.2 General morphology for the leaves and fruits of the key lime tree

Origin and distribution:

Lime (see also Figure 3.2) is originated from South-east Asia around 4000 BC and its native home is the Indo-Malayan region (Nicolosi et al., 2000). Arab travelers helped in the distribution of the lime since they carried it to North Africa, then after the Crusades they helped in spreading the lime to the Mediterranean Europe (Eckert and Eaks, 1989; Usman and Khan, 2017). Then, the Portuguese and Spanish voyagers took it to America during the early sixteenth century. Lime shows wide adaptation to diverse climates and was largely naturalized in México, the Caribbean, tropical areas of South America, Central America, and the Florida Keys (Usman and Khan, 2017).

Production levels:

The world production of lemons and lime is 17218173 tonnes. The top production countries are Mexico, India, China, Argentina, Brazil, Turkey, Spain, and USA. In addition, the average production of lemons and lime is 15.8 t/ha (FAOSTAT, 2017).

Description of the plant:

Citrus aurantifolia (Christ.) Swingle is an evergreen shrubby tree that reaches 5 m height. The tree has many branches, and they often originate quite far down on the trunk. The leaves are ovate, 2.5–9 cm long. The leaves are arranged alternatively on the stem. The flower diameter is about 2.5 cm and flower colour is yellow to white with a little purple tinge on the margins. The fruit is a berry, described as a hesperidium. The fruit size is small (2-5 cm in diameter). Most limes are sensitive to cold temperatures and are drought tolerant. (Usman and Khan, 2017; Ramadugu et al., 2017)

Climatic requirements:

Lime trees are sensitive both to low and extremely high temperatures more than 45–50°C. Moreover, Lime is considered as a cold sensitive than lemon. It thrives in a warm; it grows vigorously in tropical environments and produces higher yields. In addition, it needs annual rainfall ranged from 203 to 381 mm and so on; it endures water shortage like all citrus trees (Usman and Khan, 2017).

Part II: Cultivation practices

Propagation:

Citrus trees are propagated with both sexual and asexual propagation methods. Concerning sexual propagation, the seeds are extracted from the fruits by cutting the healthy-vigorous fruits into two halves, then squeezed to get the seeds and finally washed with water. The seeds are cultivated whether to produce rootstocks or transplants. Mexican lime is propagated by asexual propagation methods since it has many advantages. It produces true to type plants with short juvenile periodsand reduces plant height so all cultural operations can be done easily, and it is resistant to the adverse climatic and soil conditions through the use of suitable rootstock. The selection of the rootstock is very important since it must be compatible with the scions used. Many rootstocks can be used such as Volkamer lemon, Cleopatra, mandarin, and sour orange. Each of them has merits and demerits, some of them are salt and freeze tolerant, vigorous, tolerant in calcareous conditions and tolerant to some diseases, i.e., Phytophthora and citrus tristeza virus, etc. while others are susceptible to nematodes and Phytophthora, etc. (Nawaz et al., 2017). Generally, T-bud grafting is the method used for propagation of lime trees.

Soil preparation:

Soil tillage improves the soil conditions, it is important to maintain relatively smooth, level ground for orchard work and harvesting. The soil must be ploughed deeply up to 1-1.5 m to break up the hard layer (Hardpans). Organic matter can be added to the soil to improve its properties and also enhances plant growth in poor soils. Then, the rows are established, and the transplants are cultivated on the middle of these rows.

Planting:

The orchard site must be in an area suitable for lime cultivation with adequate climate conditions and water supply for irrigation (Usman and Khan, 2017). According to the type of transplants, whether it produced from seeds (true to parent plants) or the rootstock variety used (dwarf or vigor), the space between the rows and between the plants in the same row, and the style of row orientation are determined. There are many styles of row orientation, i.e., square, diamond, hexagonal and quincunx systems of plantation. Generally, the transplants are cultivated with distance 5 x 5 m.

Fertilization:

In order to calculate the nutrient quantities that the plants need, soil and leaf analysis should be performed. Srivastava (2013); Srivastava and Patil (2014) showed the leaf analysis nutrients content and the nutrients optimum range percentage. Nitrogen should range between 1.8 to 2.12 %, phosphorus 0.09 to 0.13 %, potassium 0.79 to 1.43 %, calcium 2.04 to 3.12 % and magnesium 0.28 to

0.46 %. The fertilization requirements differ according to the soil analysis. Ahmed et al. (1988) using 750 g N – 200 g P_2O_5 – 500 g K_2O/tree, while Maatouk et al. (1988) recommends 1500 g N – 400 g P_2O_5 – 750 g K_2O/tree as soil application for the Egyptian balady lime cultivar. Also, it is recommended to apply the micronutrients as foliar spraying or soil application in chelated form. Molybdenum is necessary to apply for the citrus trees. Calcium is very important after the fertilization of the flowers in order to decrease the drop of the small fruits (June drop in Egypt) (Srivastava and Singh, 2009).

Irrigation:

Lime tolerates drought better than any other citrus fruit (Usman and Khan, 2017). Sprinkler and drip irrigation systems can be used in watering lime trees in orchards. The irrigation requirements differ according to the climate conditions (tropical or subtropical site). The optimal rainfall is 200-400 mm distributed all over the year (García-Sánchez et al., 2017).

Disease control:

One of the serious diseases that infect lime trees is citrus tristeza virus; the symptoms of the disease vary according to the virus strain. The first strain is tristeza, which is characterized by the decline of citrus trees grafted on sour orange rootstocks, the second type causes stem pitting (pits or groves) on trunks and twigs and the third symptom is leaf chlorosis and stunting of lime trees. This disease can be controlled by certificate a program that ensures that citrus tristeza virus is not spread with bud wood or seedlings that are used for commercial propagation. In addition, Witches broom disease of lime is one of the diseases that threat the lime cultivations. The causal agent is gram-positive prokaryote called *Candidatus phytoplasma aurantifolia* and can be transmitted by leafhoppers or psyllids. Its symptoms are production of branches and smaller leaves that are light green to yellow in colour, the infected branches do not produce any fruits, resulting in decrement of tree productivity. This disease can be controlled by quarantine procedures that prevent the spread of the disease to new areas and by using disease free seedlings.

Gummosis and foot/root rot are destructive fungal diseases that infect lime trees. These diseases are responsible for 10 – 30 % losses of citrus all over the world. Phytophthora spp. (Phytophthora nicotianae and Phytophthora citrophthora) are the main cause of citrus gummosis and foot rot. Foot rot is caused by an injury to bark otherwise gummosis is a rotting of the bark. The symptoms are characterized by forming callus around the infected area (Savita and Nagpal, 2012), also Girdling may be observed in the infected trees resulting in the death of young trees or defoliation, twig dieback and short growth flushes in older trees (Al-Sadi et al., 2017). The aforementioned diseases can be managed by irrigating the trees during the day for short periods. Removing the soil around the collar can prevent infection by these pathogens. It is recommended to use resistant rootstocks such as trifoliate orange (Al-Sadi et al., 2017).

Harvesting:

Limes are non-climacteric fruits, which ripe on the tree. However, the maturity stage at harvest has a significant impact on post-harvest storage life and quality of lime fruit. The main parameters used to grade lime fruit include shape, size, colour and physical appearance of the fruit skin, the Mexican lime fruits at maturity it is roundish in shape with a small nipple at the apex and a very light neck. It has a smooth texture and extremely thin skin. Lime fruit should be firm, with the characteristic shape of the cultivar, free from cuts, injuries, diseases, and disorders. The fruits are gathered manually either through spot picking or the entire crop at once, the fruits should be harvested close to the button by cutting with sharp scissors (Khan and Singh, 2017).

Part III: Postharvest handling

After harvesting, the fruits are collected in farm bins and transported to the pack house. At the pack house, initial operations occurred such as weighing the bins and dumping the bins in water tanks treated with chlorine (100 – 200 ppm) to avoid the contamination by decay spores. Sorting can be performed to get rid of damaged fruits. Fruit washing takes place; the fruits are moved between transverse brushes with exposure to chlorinated washing water for at least 15-20 s. Thereafter the fruits are moved under rinsing nozzles, and then treated with fungicide sprays followed by drying. Moreover, waxing treatment took place since wax helps to slow down the drying process and also gives a shine to the fruit. Subsequently sorting, grading and labelling processes are performed. Then, the fruits are packaged and finally these packages are exposed to precooling before storage or transportation (Khan and Singh, 2017).

3.1.3 Citrus limon (lemon)

Part I: General aspects

Classification:

Latin name: *Citrus limon* (L.) belongs to Rutaceae – Rue family

Common names: citronnier, lemon, citron, citronnier, limonier

Figure 3.3 General morphology of lemon fruits and leaves

Origin and distribution:

The origin of lemon (see also Figure 3.3) is unknown, but it is believed that it first grown in northwestern India. It has been introduced and widely spreaded in Arabs and Mediterranean region at the era of 1000 and 1150 A.D, then after the Crusades helped in spreading the lemon to the Mediterranean Europe. By 1493, seeds of lemon were transferred to Hispaniola by Christopher Columbus. Then, the Portuguese and Spanish voyagers took it to America (Morton, 1987). It is capable to grow from warm temperatures to tropical conditions, and its fruits are edible.

Production levels:

World production of lemons (combined with limes for reporting) was 17.2 million tonnes. The top producers – Mexico, India, China, Argentina, Brazil, and Turkey – collectively accounted for 65% of global production. In addition, the average production of lemons and lime is 15.8 t/ha (FAOSTAT, 2017).

South Africa, Zimbabwe, Madagascar and Eswatini are the southern Africa countries that produce lemons (FAOSTAT, 2017). In South Africa the main lemon production areas are Eastern Cape and Limpopo provinces (Sikuka, 2017)

Description of the plant:

Citrus limon (L.) Burm. F. is small tree that retains its leaves green throughout the year. It reaches 3-6 m height. The leaves are long ovate, 6.25-11.25 cm long. The leaves are arranged alternatively on the stem. The flowers found in clusters (2 flowers or more) or may be single flower originated from the leaf axillary buds. The fruit is a berry, described as a hesperidium. The fruits are light-yellow, juicy, acidic and oval in shape (7 -12) cm long. The peel is aromatic with dotted oil glands and about 6-10 mm thickness (Morton, 1987).

Climatic requirements:

Regarding production of citrus commercially, all climates including tropical, sub-tropical as Mediterranean area and semi-tropical, as Brazil, regions are convenient. Citrus cultivation requires a temperature range of 25-30°C, while it requires at least 15°C in cold months. Furthermore, continued dry times squeeze to irrigate many times more than normally. (http://tropical.theferns.info/viewtropical.php?id=Citrus+limon).

Generally, Lemon is a subtropical plant that grows well at temperatures between 26–28°C. Lemon trees are susceptible to cold injury. As lemon considered cold sensitive tree than orange tree, trees and fruit will be damaged or killed by freezing conditions if they are not protected and there is no recovering can be produced after this injury (Morton, 1987).

Soil requirements:

Heavy loam soil with providing of compost is preferable for lemon growth as well as adding sand with sun furnishing. The optimum pH is 5-6 but lemon can grow in a wide range from acidic to alkaline soils (pH, 4.8-8.3). Trees tolerate drought conditions but perform poorly in water-logged soil. Lemon trees grow best when positioned in full sunlight. Hardness can be carried out by budding to produce hardier species as *C. ichangensis*, *C. aurantium* and *C. ichangensis* to become cold tolerants.

Part II: Cultivation practices

Propagation:

Citrus trees are propagated with both sexual and asexual propagation methods. Concerning sexual propagation, the seeds are extracted from the fruits by cutting the healthy-vigorous fruits into two halves, then squeeze it to get the seeds and finally washed with water. The seeds are cultivated whether to produce rootstocks or transplants true to the parent. Commercially, the lemon is propagated by asexual propagation methods, as asexual propagation has many advantages. The rough lemon is widely grown from seed to produce rootstocks that the commercial lemons are budded on. Generally, T-bud grafting is the method used for propagation of lemon trees on rough lemon and Cleopatra rootstocks. Budding should be carried out when seedling stems have reached the diameter of a pencil (6–9 mm) and at a time when the bark of the rootstock can be easily peeled from the plant (Morton, 1987; Nawaz et al., 2017). Cutting is the easy way for growing of this species. Cutting should be prepared using semi-mature wood in July to August in the farm, while layering can be carried out in October.

Soil preparation:

Soil tillage improves the soil conditions, it is important to maintain relatively smooth, level ground for orchard work and harvesting. Trees grow best when planted in a well-drained sandy loam with a pH between 5.5 and 6.5. Soil must be deep enough to permit adequate root development. The soil must be ploughed deeply up to 1-1.5 m to break up the hard layer (Hardpans). The lemon tree tolerates very infertile and poor soil. Organic matter can be added to the soil in order to improve the soil properties also it enhances the growth of the plants in poor soils. Then the rows are established, and the transplants are cultivated on the middle of these rows (Morton, 1987).

Planting:

The orchard site must be located in an area suitable for lemon cultivation with adequate climate conditions and water supply for irrigation (Usman and Khan 2017). According to the type of transplants, whether it produced from seeds (true to parent plants) or the rootstock variety used (dwarf or vigor), the space between the rows and between the plants in the same row, and the style of row orientation are determined. There are many styles of row orientation, i.e. square, diamond, hexagonal and quincunx systems of plantation. Generally, the transplants are cultivated with distance7.5 x 7.5 m (Morton, 1987).

Fertilization:

In order to calculate the nutrient quantities that the plants need, soil and leaf analysis should be performed. The fertilization requirements differ according to the soil analysis. It is recommended to add 75 -109 kg N, 33-50 Kg P_2O_5 and 75 -109 kg K_2O (Hellagrolip, 2019 electronic site). Also, it is recommended to apply the micronutrients as foliar spraying or soil application in chelated form. Molybdenum is necessary to apply for the citrus trees as foliar spraying. Calcium is very important after the fertilization of the flowers in order to decrease the drop of the small fruits, also zinc is added as zinc sulphate as soil application (810 g / tree), while manganese is added as manganese sulphate as foliar spraying (García-Sánchezet et al., 2017)

Irrigation:

According to the environmental factors, the irrigation requirements are determined. Sprinkler and drip irrigation systems can be used for irrigation lemon trees in orchards. During the flowering and fruiting stages suitable soil moisture should be maintained.

Disease control:

Lemon trees is infected by citrus tristeza virus, the symptoms of the disease vary according to the virus strain. It may be decline of citrus trees grafted on sour orange rootstocks, stem pitting (pits or groves) on trunks and twigs and chlorosis and stunting of lemon trees. This disease can be controlled by certificate a program that ensures that citrus tristeza virus is not spread with bud wood or seedlings that are used for commercial propagation. In addition, Anthracnose caused by Colleto trichumgloeosporioides, it is a fungus disease that leads to dieback of twigs, premature leaf drop, and dark staining on fruit. This disease can be controlled by using appropriate fungicide. Also, Mal secco is a fungal (*Phomatracheiphila*) disease, its symptoms are leaf veins chlorosis, and leaves wilting which shed from plant and the infected bark may turn silver-grey in color. This disease is major in the Mediterranean lemon cultivations. It can be prevented from spreading into new areas by using of clean planting material, pruning the infected trees as soon as possible, avoid using overhead irrigation systems and spraying trees with copper fungicides protect it from the disease. Gummosis and foot/root rot are destructive fungal diseases that infect lemon trees. These diseases are responsible for 10 – 30 % losses of citrus all over the world. *Phytophthora* spp. (*Phytophthoranicotianae* and *Phytophthoracitrophthora*) are the main cause of citrus gummosis and foot rot. Foot rot is caused by an injury to bark otherwise gummosis is a rotting of the bark. The symptoms are characterized by forming callus around the infected area (Savita and Nagpal, 2012). Also, Girdling may be observed in the infected trees resulting in the death of young trees or defoliation, twig dieback and short growth flushes in older trees (Al-Sadi et al., 2017). These diseases can be managed by irrigating the trees during the day for short periods. Removing the soil around the collar can prevent infection by these pathogens. It is recommended to use resistant rootstocks such as trifoliate orange (Al-Sadi et al., 2017).

Harvesting:

Lemons are non-climacteric fruits, which ripe on the tree. However, the maturity stage at harvest has a significant impact on post-harvest storage life and quality of lemon fruit. The main parameters used to grade lemon fruit include shape, size, colour and physical appearance of the fruit skin. It has a smooth texture and extremely thin skin. Lemon fruit should be firm, with the characteristic shape of the cultivar, free from cuts, injuries, diseases and disorders. The fruits are gathered manually either through spot picking or the entire crop at once, the fruits should be harvested close to the button by cutting with sharp scissors (Khanand Singh, 2017).

Part III: Postharvest handling

After harvesting, the fruits are collected in farm bins and then transported to the pack house. At the pack house, initial operations occurred such as weighing the bins and dumping the bins in water tanks treated with chlorine (100 – 200 ppm) to avoid the contaminationby decay spores. Sorting can be performed to get rid of damaged fruits. Fruit washing takes place; the fruits are moved between transverse brushes with exposure to chlorinated washing water for at least 15-20 s. Thereafter the fruits are moved under rinsing nozzles, and then treated with fungicide sprays followed by drying. Moreover, waxing treatment took place since wax helps to slow down the drying process, and also gives a shine to the fruit. Subsequently, sorting, grading and labelling processes are performed. Then, the fruits are packaged and finally these packages are exposed to precooling before storage or transportation (Khan and Singh, 2017).

Part IV: Utilization

Lemon has many bioactive components such as citric, ascorbic acid, minerals, flavonoids and essential oils (Di Vaio et al., 2010). Lemon juice and the essential oils which extracted from the peel or by distillation of leaves are applied as an aroma enhancer in beverages, bakery, and food products, also used as a flavoring agent to mask the unpleasant taste of drugs in pharmaceutical, and as fragrance in perfumery and cosmetic industries.

Lemon fruit, juice and peel are used to make medicines. Lemon is used to treat scurvy, a condition caused by not having enough vitamin C. Lemon is also used for the common cold and flu, H1N1 (swine) flu, stomach upset, vomiting from pregnancy and kidney stones. It is also used to aid digestion, reduce hay fever symptomsand reduce pain and swelling (WebMD, 2019 electronic site).

3.1.4 Citrus maxima (pomelo)

Part I: General aspects

Classification:

Latin name: *Citrus maxima* belongs to Rutaceae family

Commonly known as pomelo, shaddock, pummelo, pumelo, chinese grapefruit

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Figure 3.4 General morphology of the fruit of pomelo tree

Origin and distribution:

Pomelo (see also Figure 3.4) is a natural, i.e., non-hybrid, citrus fruit, similar in appearance to a large grapefruit, native to South and Southeast Asia. Pummelo is one of the original citrus species from which the rest of cultivated citrus have been hybridized.

Production levels:

Yields greatly depend on cultivar and environment, but there seems to be no reason why the potential yield of Pummelo should be lower than for other citrus species. Thai sources put yield at 70-100 fruits per tree per year, equivalent to the 20 t/ha per year reported as a good yield in Malaysia.

Description of the plant:

Tree height ranged from 16 to 50 ft (5-15 m) with slight circuitous trunk of 4-12 inches.

Leaves: large evergreen oblong to elliptic leaves, 10.5 to 20 cm (4 to 8 in) long. Frequently emarginated, pubescent beneath, acute apex, asymmetric base, entire margin, characteristic odor. Petioles: broadly winged.

Flowers: Large, White Stamens: 16-24

Fruit: large, pale yellow, globose or pyriform, rind thick, pulp varying in color from crimson to pale pink or yellow (Evans, 1997; Khandelwal, 2003)

Climatic requirements:

The optimum growth can be obtained with optimal conditions. The optimum temperature range is 25–30°C with rainfall range from 1,500 to 1,800 mm, while altitude should not exceed 0-400 m.

Soil Requirements:

Because of *Citrus maxima* coastal habitant, soil rich in silt or flood clay loam soil covered with sand whereas it quite tolerant to unpleasant water operated inlands through redundant tides. Salt free and medium or deep fertile soil is preferable for growing tree although it is considered wide range tolerant tree. It is also grown in limestone lands and produce fruits in Bahamas and Florida.

Part II: Cultivation practices

Propagation:

Citrus maxima is usually grafted onto other citrus rootstocks, but may be grown from seed (Julia, 1987). Though the seeds of the Pomelo are mono embryonic, producing seedlings identical to their parents, and therefore seeds can be used for growing of Pomelo and seeds can be kept under cooling (5°C) for eighty days at and with moderate relative humidity (Julia, 1987). Propagation of high-quality varieties can be carried out using air-layering or by using rootstocks in budding onto. Although many trees in home gardens are raised from seed, the common propagation method in South-East Asia is air layering. When certified virus-tested mother trees become available, budding is recommended. Pomelo seedlings of sufficiently uniform populations can be used as rootstocks. In the Philippines shield budding is already the standard method, using rootstocks of calamandarin (believed to be a hybrid of calamondin and mandarin).

Soil preparation:

In many countries as southeastern Asia and Thailand, Pomelo beds were prepared through digging of canals and ditches for transportation and draining routes. Fast growing crops, sugarcane, peanuts, and banana, can be grown before cultivation of Pomelo trees by three to five years through beds preparation. On the other hand, betel nuts and coconut palms can be grown for shading of young trees and can be removed after three to five years and sometimes remained to ten to fifteen years and some growers shaded Pomelo by cultivating colurrinar (Erythrina fusca) trees in between Pomelo trees, as Pomelo is cultivated in 3-4.5 m in apart. These cultivated trees keep stringy of root system and enriching soil with fallen leaves. Hoeing is used for removing of weeds. The standard fertilizer is manure also; burned rice ash is added to trees for gradual seeping to root system. As air-layered trees have fewer spread characters, they should be refined.

Planting:

Trees are spaced 8-10 m x 6-8 m, depending on vigour, on well-prepared land; they are shaded and watered frequently until they are established. The planting material is cut back, especially if bare-rooted.

Fertilization:

Fertilizer requirements of citrus also apply to Pomelo, including attention to magnesium and micro-nutrients (Zn, Mn, Cu, B). An annual or biennial dressing with manure forms a good basis. In Nakhon Prathom, Thailand growers are advised to apply about 5 kg N-P-K 16-16-16 per tree per year in bi-monthly applications and foliar fertilizer for every new flush. In the last dressings before harvest potassium-rich N-P-K 13-13-21 is used to improve fruit taste. Elsewhere 2 fertilizer dressings are recommended, the first before flowering and the second 4-6 months later.

Irrigation:

Irrigation is critical from before flowering until after harvest to supplement rain. During the following dry period irrigation is delayed till the timber show signs of wilting. It is commonplace to force early flowering through irrigating the wilting trees, furnished the water supply is secure till the rainy season starts off evolved again. Forcing the trees to strengthen the harvest has its limitations, because it is hard to sustain new shoot growth and flowering for the duration of the recent dry months previous the rains.

Disease control:

It can be injured by insects, which cause excretion of sugary sticky substances, facilitating sooty mold development on it. Pomelo trees also affect orange tree although some resistant varieties founded by Walter Swingle when he visited China, Philippines, and Japan. In contrast, old trees in Malaya are infected with Phytophthora that caused root rot.

Harvesting:

Flowering of Pomelo trees may be repeated from two times to four times a year. Fruit harvesting time is repeated four times in old world countries, the mature crop is harvested at November, while ripen of other seasons produced less seeds with excellent quality. This scene is observed in Florida as mature fruit are harvested from November to February, while in spring fewer crops are collected. Thailand generally picked fruits at the beginning of coloration. The pale pores and skin of immature fruits became brighter and shinier upon maturity with oil gland ending up and extra splendid. The mentioned changes point to the end of fruit in which fruit completed its flavor.

Part III: Post-harvest handling

In case of storage for short periods, fruits can be stored under shaded ventilate and dry shed as the thick peel helps in keeping. Deep wrinkles will be appeared after three months of storage with more juicer fruits and they will became more flavor and charming, while storage for a much long time produced bitter taste. Wrapping of fruits by paper and keeping them in ventilate and well condition allows keeping fruits for six to eight months, which is suitable for ship transportation. In houses of old Chinese, fruits kept for a year by hanging with good quality.

Part IV: Utilization

Labors involved in the harvesting of fruits caused skin segment and eat juicy plups. Therefore, the segmented skin can be used in making of dessert and salad or used in preservation. Juice extracted from fruits can be used in making candy. Limonene, citral, geraniol, cadinene, linalool and terpene aldehydes presented in citrus peels essential oil are also presented in pummelo peels which cause irritation and dermatitis in some cases with extensive contact. Essence extracted from the aromatic pummel flowers is consumed in perfume industry in North Vietnam, whereas its wood is hard, streaky and heavy so it is preferable in making handles of tools as cooking pans. Decoction prepared from flowers, peel and leaves is used as calmative agent and chronic cough in Southeast Asia and Philippines, whereas hot decoction of leaf is used in treating swilling and ulcers. The fruit juice is taken as a febrifuge. Seeds also are used in treating cough, lumbago and dyspepsia, while sugary sticky substance exerted from declined trees is used in Brazil for treating cough.

3.1.5 Citrus reticulate (mandarin orange)

Part I: General aspects

Classification:

Scientific name: *Citrus reticulata* belongs to Rutaceae family

Common name: mandarin orange, mandarin, mandarine

Figure 3.5. General morphology of Citrus reticulate

Origin and distribution:

Mandarin (see also Figure 3.5) is a widely cultivated fruit tree in many warm temperate to tropical areas.

Production levels:

The average yield of ripe fruit mandarin per tree is 79kg, while the world production is estimated to be 33.4 million tonne yearly. China produces 54% of world mandarin yield. Turkey, Brazil, Egypt, Morocco, and Spain produce one million tonnes a year.

Description of the plant:

Citrus reticulate, is middle sized tree and has 7.6 m in length, prickle trunk and branches, shiny green leaves, short petioles, wingless mostly and single or small group flower is in leaf axils. Citrus species are mostly self-fertile by bee or parthenocarpic. Fruit of mandarin are small, 4-8 cm with color between orange, yellowish orange and reddish orange.

Climatic requirements:

Mandarin (*Citrus reticulata*) is a widely cultivated fruit tree in many warm temperate to tropical areas. The optimal temperatures for citrus cultivation range between 25 - 30°C, with the coldest month having an average minimum of at least 15°C. Growth generally ceases below 13°C and above 38°C.

Soil requirements:

Heavy loam soil is plausible for mandarin with addition of compost and sand accompanied with sunny position (Chittendon, 1956). It requires acidic medium with pH 5-6, but it tolerates pH range 4.3-8.3. Water-logged soil is not suitable as it isn't tolerate it (Simmons, 1972).

Part II: Cultivation practices

Propagation:

They are many methods for mandarin propagation including layering, half ripe wood cuttings and seed propagation.

Soil preparation:

Cow dung manure is added at 10 kg to a pit with size 80 x 80 x 80 cm at the top pit soil. After this preparation, oranges will then be added with a distance 7 m in between rows and 7 m in a part. The type of soil is considered a factor to select plant distance, 120 plants/acre can be planted in less space cultivation. After cultivation, watering must be applied.

Planting:

It is best to cultivate ripe seeds in container, after thoroughly rinsing them (Bird, 1990; Huxley, 1992). It requires two to three weeks for the seeds to germinate. To keep seedlings rom damping off, they should be watered carefully with keeping ventilation. The seed is usually polyembryonic, two or more seedlings can be raised by one seed, and they are genetically identical to the parent but they do not usually carry any virus that might be present in the parent plant (Huxley, 1992). When it is large enough to handle, the plants should be placed separately in pots to maintain the best growth until they are 10 cm or more high before being planted in their permanent places. On the other hand, half ripped cuttings can be carried out in July/August. This species grows easily from cuttings (Huxley, 1992). Layering takes place in October.

According to Hassanein and Azooz (2003) promising germination can be achieved by planting seeds directly after obtaining them from citrus fruit in January, at a constant temperature of 25°C. Using seed drying reduces the germination/ seed percentage. When seeds are germinated in medium containing benzylaminopurine at 0.5 mg/dm^3 better germination can be achieved compared to planting in the soil. On the other hand, cuttings produced from shoots can be planted in medium containing B5 (1 mg/dm^3), kinetin (0.5 mg/dm^3) and naphthalene acetic acid (0.5 mg/dm^3) to obtain best shoots grow. Root cuttings can be placed in medium containing benzylaminopurine at 0.25 mg/dm^3, naphthalene acetic acid at 1 mg/dm^3 as well as isobutyric acid at 1 mg/dm^3. Root growth in light is better than dark. Transferring cuttings of shoots or roots will be successful after three weeks of adaptation.

Fertilization:

Citrus plant requires macronutrients as potassium, phosphorus and nitrogen as well as micro-nutrients as zinc, magnesium and iron to obtain good vegetation and development. The use of organic manure helps in obtaining healthy trees with delicious fruits. The application dosage shown in Table 3.1 has the best requirements for good production.

Table 3.1 Dose of fertizer for citrus reticulate

Orange Plant Age	Year-wise Fertilizer dose (g per plant)		
	N	P	K
1st Year	150	50	25
2nd Year	300	100	50
3rd Year	450	150	75
4th Year & above	600	200	100

Producers have to be sure about suitable addition of organic fertilizers.

Irrigation:

Citrus plant prefers watering as banana, but the required water quantity depends on plant age, climatic conditions and soil type. The usual interval for orange trees is seven days in summer season while it is ten days in winter. Citrus plant should be irrigated after plantation with avoiding logging as it is susceptible to stagnancy. The minimum requirement for fully grown is twenty times yearly. It is plausible to use drip system for irrigation.

The top inch of soil should be dry without completely drying the soil. The plant needs more water during the warmer months of the year. Young trees need water more often than older trees, although older trees need more water overall. A sign of insufficient water is that the leaves become dull and curve inwards from the edges.

Disease control:

Gummosis, twig blight, damping off, root and collar rot are main diseases that are commonly observed in plant growth. Bavistin, Ridomil MZ 72, Benomyl, etc. can prevent the infection of trees.

Other cultivation practices:

Mulch: In spring, last year's layer must be removed, and a new organic layer must be placed to reduce water loss and reduce weeds. The protective cover should be kept at least 6" away from the trunk to prevent the collar from rotting.

All fruits must be removed at the first planting. All fruits that grow in the first three years must be removed so that the plant directs its energy to the growing roots, branches and leaves. Watering should be done on a weekly basis between June and September. It is best to keep the first inches at the top of the soil dry. For pruning, it is acceptable to apply in the spring to maintain maximum leaf food storage in mid-winter, as early pruning reduces flowering and fruit set. The removal of young fruits in heavy years should be carried out in the spring. Hand puling method is used to remove weeds above the root area; tools must be avoided to prevent the damage of shallow roots.

The branches and trunk that are not shaded should be painted to avoid sunshine during shaping. Some flowers or fruits will fall as the citrus plant adjusts their loads.

Harvesting:

Generally, the mandarin plant matures at the age of one year, when the mandarins begin their flowering and time, but with a lower fruit load compared to the following harvest seasons. Harvest usually begins in the fourth year. The economic mandarin life is estimated at twenty-five years. The mandarin can be harvested with delicious taste three times, in rainy season, autumn and summer.

The collection time is depending on cultivar type as some of them must be remained until full coloring to get ripe fruit, whereas other can be collected at light green color as Satsumas. Mandarins must be remained on tree until full ripe. Testing one fruit from tree is an acceptable method to determine the readiness of the fruits. If they are sour, they must be remained on the tree. The ripe time is varied from year to another according to agro-climatic condition that trees exposed to them. The fruit remained on the tree will be sweeter than early collected fruits, as the acidity decrease with time. The fruit can be removed from the tree using clippers by cutting the stem close to the fruit.

Part III: Post-harvest handling

Storage after harvest: mandarins can be refrigerated up to six weeks. They can be kept at room temperature one week.

Part IV: Utilization

Citrus species contain a wide range of active ingredients and research is still underway in finding uses for them. They are rich in vitamin C, flavonoids, acids, and volatile oils. Citrus species contain coumarins as bergapten, which stimulises sensitivity to sunlight. It promotes skin pigmentation and produces allergy for some peoples.

Fruits are considered astringent, antiemetic, tonic, aphrodisiac, and laxative, while flowers are considered as stimulant. Pericarp part is used as anti-asthmatic, anti-inflammatory, antiscorbutic, anti-cholesterolemic, antitussive, stomachic, carminative, analgesic, expectorant and antiseptic. In addition, it is used in treating gastro-intestinal distension, hiccup and vomiting cough with profuse phlegm and dyspepsia. On the other hand, endocarp also is used as expectorant and as carminative. It is used in treating gastro-intestinal distension, dyspepsia, profuse phlegm, and cough. The green exocarp of un-ripped fruit is play as stomachic and carminative, chest pain treatment and hypochondrium, liver and spleen swelling, liver cirrhosis, gastro-intestinal distension and in treating lumbago, hernia, mastitis, testis swelling pain. The essential oil (0.5%) is used as flavoring agent as well as in perfume and medicine industries. Leaves or twigs essential oil is called petitgrain oil.

3.1.6 Eriobotrya japonica (loquat)

Part I: General aspects

Classification:

Latin name: *Eriobotrya japonica* belongs to Rosaceae family

Commonly known as loquat, Japanese medlar, Japanese plum, Chinese plum, pipa and nespola

Figure 3.6 General morphology of the loquat tree fruits and leaves

Origin and distribution:

Indigenous to south-eastern China and Japan, where it has been cultivated for centuries, loquat (see also Figure 3.6) is now widely grown across India and South-East Asia, the East Indies, Australia, New Zealand, Madagascar, the Mediterranean region (particularly Spain and Turkey) and South Africa. Although it was introduced as a horticultural tree, it can be found naturalized in India, southern Asia, the Mediterranean region, Australia, New Zealand, Africa, North, Central and South America, the West Indies and on many islands in the Indian and the Pacific Ocean. Generally, loquats are found between latitudes 20° and 35° north and south but can be cultivated up to latitude of 45° in maritime climates (Hiep and Verheij, 1991; Janick and Paull, 2008; Flora of China, 2016; USDA-ARS, 2018).

Production levels:

Eriobotrya japonica is widely cultivated, and its fruits are commercialized around the world. Loquat fruits are produced in quantity in China and Japan. Japan, one of the major producers, reported annual crops ranging from 7,000 to 17,400 t in the year (https://www.cabi.org/isc/datasheet/20559#todistribution). In India the average fruit yield per tree is 16 - 20 kilos per year, but yields can be up to about 100 kilos per tree. Average yield in Japan is about 8 t/ha and the highest yield recorded is 25 t/ha in Israel.

Plant Description:

Eriobotrya japonica is a big evergreen shrub or small tree, its crown is circular, trunk is short with mystic twigs. The tree can grow to 5–10 m (16–33 ft) tall, but is often smaller, about 3–4 m (10–13 ft). The fruits begin to ripen during spring to summer depending on the temperature in the area. The leaves are alternate, simple, 10–25 cm (4–10 in) long, dark green, tough and leathery in texture, with a serrated margin, and densely velvety-hairy below with thick yellow-brown pubescence; the new leaves are also densely pubescent above, but this soon rubs off (Flora of China, 2016; Janick and Paull, 2008).

Loquats differentiate to other fruit trees as their flowers appear in autumn or early winter, and the fruits are ripe at any time from early spring to early summer. The flowers are 2 cm (bit less than 1 in) in diameter, white, with five petals, and produced in stiff panicles of three to ten flowers. The flowers have a sweet, heady aroma that can be smelled from a distance. Loquat fruits, growing in clusters, are oval, rounded, or pear-shaped, 3–5 cm (1–2 in) in long, with a soft or silky, orange or yellow, sometimes red-blushed skin. The succulent, tangy flesh is white, yellow or orange and sweet to sub-acid or acid, depending on the cultivar.

Each fruit contains from 1-10 ovules, with 3-5 being most common. A variable number of the ovules mature into large brown seeds (with different numbers of seeds appearing in each fruit on the same tree, usually between 1 and 4).

The fruits are the sweetest when soft and orange. The flavor is a mixture of peach, citrus and mild mango (Flora of China, 2016; Janick and Paull, 2008).

Climate Requirements:

The cultivation temperature range is between -3°C in winter to 35°C in summer season. The trees could remain alive up to -10°C, but -12°C is considered lethal for the trees (Morton, 1987; Hiep and Verheij, 1991; Orwa et al., 2009).

Loquat fruits and flowers are partially susceptible for temperature; therefore, exposing ovules to -4°C in early fruits kill them. On the other hand, trees require rainfalls ranged from 1000 to 1200 mm per year with suitable humidity level.

Soil Requirements:

This tree prefers well-drained soil, but can be grow in different soil types, loam, sand and clay (Morton, 1987) and can be also grown in varied pH ranges including acidic, alkaline and neutral soils in semi shade and sunny area. In addition, it can be grown in moist or dry soil and tolerate the exposure to maritime (Janick and Paull, 2008; Orwa et al., 2009).

Part II: Cultivation practices

Propagation:

Cold fame is suitable for sowing seeds in spring as it is ripe, and they remain moist (Huxley, 1992). Seeds should be soaked 24 hrs before sowing in green house at warm condition in late winter (Sheat, 1948; Dirr and Heuser, 1987). The germination period usually does not exceed 1-4 months at warm conditions (20°C). Large seedlings should be transferred in individual pots in the same greenhouse for their first winter. After the last frost time, at starting summertime or in late spring, plants can be transferred to their perpetual positions. Cuttings should be prepared from semi mature wood in July-August (Huxley, 1992). Cuttings of spring are prepared from softwood (Sheat, 1948).

Planting:

It is easy to transplant loquats. It needs soil preparation, and each plant area should be surrounded by 4-foot loosen soil circle and then the hole for thetree is dug. Each plant must be removed from its pot just before the cultivation directly. The pots should be rinsed and the roots should be exposed, while keeping some of medium. After that, plants will be placed in original height not in depth. The new soil should be in contact with roots and fill out the hole. After transplanting, plats should be well irrigated with mulch to prohibit the growing of weeds at the base.

If trees are cultivated in containers, they must reconstitute yearly, refill their soils and transfer themto larger containers if it is required. For dwarfing, the tape root should refine slightly and carefully to prohibit bounding of roots; much removing is not plausible because it can injure the tree (Huxley, 1992).

Fertilization:

It is preferable to use granular and leisurely fertilizers with fruity trees. Quinces, apple and pears are close to the tree. If the fertilizers of fruit trees are not available, standard lawn fertilizers can be provided with preventing weed or using killers of weeds. Three application times should be provided at the first year after the tree becomes established in order to be sure that roots have penetrated the soil in depth and then start fertilizers addition. In the following years, thumb rule is considered as a good tool for measuring tree trunk diameter that is used for determination of fertilizers requirement. One fertilizer pound is used annually for one inch of diameter of tree trunk in the four feet cycle around the tree and it has to be applied consequently through the year course with well water application to facilitate penetration of fertilizer in root area and then absorbing them by roots.

Irrigation:

This tree requires huge amounts of water at the first year of cultivation; therefore, it should be watered tardily four times weekly during the beginning. The amount and frequency of water to be reduced over time. In case they depend on rainfall, loquat requires only 20-45 inches of water annually, therefore it will grow well in grounds that reache these levels. In spring season, the flowers slowly become fruits so that they need to be irrigated regularly. This irrigation can be performed using hosepipe that allow moisture around roots. Water should be turned off when water drains away. This should be repeated many times until fruits start their maturity and induce a sweety taste and higher juice content, especially in case of irregular rain. Whereas with enough rainfall, additional irrigation is not required. In summer season with high tepmperatures, drip irrigation is required to avoid side effects of sunrays. Dripping water is very promising for this target as well as it can be used to prevent splashing of water around tree.

Disease control:

As birds like mature loquat, it is preferable to cover the fruits. Although fruits are not sensitive to many diseases or infections, they may be attached by both pear and fire blight. Furthermore, fire blight is commonly observed in moist and rainy areas in early summer or late spring that can be inherited to young shoots by bees which cause browning and kill the leaves. The infected tree should be destroyed. Using bactericidal preparations can help in avoiding fire blight. Removing the infected tree will keep other healthy tree from infections and prohibit spreading of the infection. Pear flight is widely spread in California. The anti-bacterial treatment of the two types of blight is the same. In addition, fungal leaves spots can affect the tree, if the canopy is not penetrated by an airflow to reach the centre of the tree (Lindley, 1821).

Harvesting:

Mature loquats are larger than the unmature ones. Mature loquat characterized by its darker skin color and the increased softness of the fruit. Riped loquat may fall off the tree, if they remain on without harvesting. Fruits can be easily harvested by trimming. The entire clumps can be removed together at once. Mature fruits are juicy and sweet, while unripe fruits have less plausible taste characters. The over-mature fruits are soft and very sweet.

Part III: Postharvest handling

Mature fruits have a short lifetime from harvesting until eating so they can be sotred by freezing, kept in freezer bags until use. They can also be preserved by making jam and syrup. Additional acid may be required for canning purposes. Additionally, fruits are used for making liqueurs and wines and can be used as flavoring agent.

Part IV: Utilization

Loquat is considered as rich plant in vitamin B6, vitamin A, potassium, dietary fibers, and manganese, while it is poor in sodium. On the other hand, its young leaves and seeds considered as slight poisoning

material as they contain cyano-glycosides such as amygdalin. Therefore, it is better to stop eating it, when bitter taste is detected (Shepherd, 1974).
Popularly, loquat is used in treating cough in the Far-East (Bown, 1995). Its leaves are used as antibacterial, anti-viral, astringent, antitussive, anti-anemia, expectorant, diuretic, and analgesic agent (Chiej, 1984).
Leaves decoction and young shoots decoction are used as astringent for intestine and in treating cough, fever, cold, bronchitis as well as in mouth wash preparation (Chiej, 1984). Before using leaves, they should go through air drying and removing of hairs to prohibit throat irritation (Bown, 1995).

3.1.7 Ficus carica (fig)

Part I: General Aspects

Classification:

Latin name: *Ficus carica* belongs to Moraceae family

Commonly known as fig, common fig

Figure 3.7 General morphology of the fig fruits

Origin and distribution:

The fig (see also Figure 3.7) was perhaps first brought into cultivation in the southern parts of the Arabian Peninsula by at least 3000 BC. It later spread into Iran, Syria and Turkey and into all the Mediterranean countries. During the age of exploration following the discovery of America by Columbus, the fig was taken to most subtropical areas of the western hemisphere. Baba¬Dag in Crimea abandoned in 1783. They are considered to be descendants of figs that have been cultivated on the plateau from the 12th century.

Production levels:

In 2018, world production of raw figs was about 1.15 million tonnes, with Turkey accounting for 26% of world production, followed by Egypt and Morocco, which collectively accounted for 54% of world production (https://en.wikipedia.org/wiki/Common_fig#cite_note-fao17-36).

Description of the plant:

Ficus carica is a gynodioecious, i. e., functionally dioecious, deciduous tree or large shrub that grows up to 7–10 m, with smooth white bark. Its fragrant foliage is 12–25 cm long and 10–18 cm wide, and deeply lobed with 3 or 5 lobes. The complex inflorescence consists of a hollow fleshy structure denominated the "syconium", which is lined with numerous unisexual flowers. Although commonly denominated a "fruit", the fig is in truth the in frutescence or scion of the tree, known as a "false fruit" or "multiple fruit", which bears the flowers and seeds. It is a hollow-ended stem that contains many flowers. The fruit is 3–5 cm long, with a green skin that sometimes ripens toward purple or brown. *Ficus carica* has milky sap, thus rendering it a latecomer. The sap of the green parts is an irritant to human skin (https://en.wikipedia.org/wiki/Common_fig).

Climatic requirements:

The fig is a deciduous and sub-tropical tree. The fruit quality deteriorates beyond 39℃, although the plants can survive at temperature up to 45℃. It growths well when the temperature is above 15 - 21℃, although the mature tree can withstand low temperature up to 4℃. Quality figs are produced in aareas with dry climate, especially during fruit development and ripening. High humidity combined with low temperature usually results in fruit splitting and low fruit quality.

Soil requirements:

Fig is one of the most salt and drought tolerant crops. Medium to heavy, calcareous, well drained, deep (about 1 m) soil having pH of 7-8 is ideally suited for cultivation of figs. (https://pfaf.org/user/Plant.aspx?LatinName=Ficus+carica).

Part II: cultivation practices

Propagation:

Sowing of *Ficus* is applied in snug greenhouse in spring season. When seedlings become durable enough to be handled, they could be transplanted over the winter season (of their first year). They are always transferred in late spring to protect them from hazards that can be produced by the first outdoors in cold medium. Cuttings are prepared from ripe wood (10-12 cm) in winter and kept frozen and then placed in single pot/each cut (https://pfaf.org/user/Plant.aspx?LatinName=Ficus+carica).

Soil preparation:

Figs should be planted in well-drained soils but can be successfully grown either in coarse sandy soils or in relatively heavy clay soils. It should be noted that in sandy soils, fig trees can suffer extensive damage from root knot nematodes. Root-knot nematodes, *Meloidogynesp*, are microscopic, soil inhabiting worms which attack the plant's root system. Root-knot nematodes attack and feed on roots, causing them to swell or gall; thus, interfering with normal uptake of water and nutrients. Fig tree root systems are fairly shallow, but extensive. Accordingly, figs benefit from organic mulch to conserve soil moisture and improved soil structure. Care must be taken when cultivating near the trees.

Planting:

Fig is planted at a spacing of 5 x 5 m. Pits of 0.6 cu.m are dug for planting the cuttings. Planting season varies from place to place i.e. South India (August and September), Western India (June andJuly) and North India (January and February).

Fertilization:

Vegetative growth stage is critical for good fruit quality. Sufficient nutrients must be supplied to ensure that the foliage is healthy, as it shelters the fruit from sunburn during summer. Small fortnightly applications of water-soluble fertilizers can be applied to the irrigation system throughout the growing season. Complete fertilizers with an N:P:K ratio of approximately 20:5:20 are commonly used. Leaf analysis and soil tests can be used to monitor nutrition and tailor fertilizer needs to plant requirements.

Irrigation:

Fig can sustain heat and drought. Irrigation is necessary for commercial production in a timely manner. During summer, ideal flood irrigation intervals is at an interval of 10-12 days. However, if drip irrigation is adopted 15-20 litres of water/day/plant should be provided. Frequent irrigation leading to excess soil moisture will cause fruit’s splitting. During fruit ripening, the plants should not be watered, because it will cause insipid fruits viz., fruits with bland taste.

Disease control:

Leaf Spot Diseases: To solve this problem, it is recommended to avoid overhead watering and purchasing only disease-free seedlings. Fungal diseases such as fig rust, leaf blight and pink blight: To reduce favorable conditions for fungal germination, good sanitation practices should be applied, and special attention should be given to the amount of irrigation water. If one plant is symptomatic, it should be destroyed. Fruit souring and insect control may prevent infection. *Alternaria* rot (surface mold) *Alternaria* spp.: rRot can be minimized by picking fruit before it becomes overripe, and reducing dust in orchards. *Aspergillus* rot: Avoid stressing trees by providing adequate irrigation and reducing dust in the orchard. *Botrytis* limb blight: Infected areas of trees should be pruned out. (https://www.gardeningknowhow.com/edible/fruits/figs/common-fig-tree-diseases.htm)

Other cultivation practices:

Fig trees can be either grown as half-standard or bush trees. The initial pruning is similar to the training of other bush top fruit, such as apples and pears. Fig trees can be trained as a fan against a wall.

Harvesting:

From the third-year commercial harvesting takes place. The yield increases with increase in canopy size of the tree and stabilizes during eighth year. The harvesting season starts in February - March and is over by May - June. The fruits are harvested in 2-3 days intervals manually. The fruits should be picked when they are soft and wilt at the neck. Milky latex exudes if the fruits are picked before proper maturity.

Part III: Post-harvest handling

Packaging in plastic films is a common practice with dried figs. The effect of sophisticated packaging methods on keeping quality of dried. Vacuum packaging had a negative effect on the product quality due to enhanced exudation and fig darkening. Storage in modified atmosphere (20% CO_2 + 80% N_2) slows the darkening of dried figs at ambient temperature as compared to air or nitrogen atmospheres. However, none of the atmosphere modification methods are as efficient as low temperature in product preservation. Dried figs are fairly durable (especially as compared to fresh fruit) and may be stored under nonrefrigerated conditions. Still, reduced temperature and intermediate humidity (4°C and RH 55% to 65%) are preferred as the ideal environment for storing dried figs. Refrigerated storage allows the product to be stored for 6 to 7.5 months, while in non-cooling conditions the quality begins to decline after 2.5 months. Other authors described successful retention of product quality at 20°C for 6 months. Figs destined for the fresh fruit market or canning should be picked when they become fully colored and still firm. The fruit should be cooled to 0°C as soon as possible. Optimum cool room temperature is between –1°C and 0°C, with 90 to 95% relative humidity. Their shelf life outside the freezer is only 1 or 2 days.

Part IV: Utilization

Ficus latex is commonly used in treating skin ulcer, warts and sore. It is also used as vermifuge and purgative with some precausions. Fruit decoction is used in the treatment of sore throat in a form of gargle, whereas the syrup produced from boiling of fig is used against swollen gum, which also used in treating abnormal growth as tumors. On the other hand, leaves decoction is considered a remedy for diabetes and kidney calcification. Both dried and fresh figs are used as laxative.

3.1.8 Malus domestica (apples)

Part I: General Aspects

Classification:

Latin name: *Malus domestica* belongs to Rosaceae family

Commonly known as apple

Figure 3.8 General morphology of the apple fruit

Origin and distribution:

Apple trees (see also Figure 3.8) are cultivated worldwide. The tree originated in Central Asia. Apples have been grown for years in Asia and Europe and were brought to North America by European colonists.

Production levels:

World production of apples is 83.1 million tonnes, where China producing 50% and Europe producing 17% of the total. Other significant producers such as United States, Turkey, and Poland produce about 3–5% of the world production. The success story of apple-growing in East Java is highlighted by statistical data indicating that production increased from 15 000 t/year from about 2 million trees to 50 000 t from 7.6 million bearing trees. Apple-growing is also on the increase in northern Thailand and gaining ground in the Philippines (Luzon); as in East Java the crop in the Philippines is grown on a cycle, which is much shorter than one year.

Description of the plant:

The tree is small and deciduous, reaching 3 to 12 m tall, with a broad, twiggy crown. In spring blossoms are produced simultaneously. The flowers are white with a pink tinge that gradually fades.

Climatic requirements:

Apple is widely cultivated in temperate zone. Warm summer conditions supply plant with its requirements for good quality production with rainfall ranged between 600 to 800 mm/ y. It required 1000 hrs of cold winter (7°C) for initiation of flowering, therefore, Far North produced apple with good characters and production, whereas it needs warm in primarily life.

Soil requirements:

Like most fruit trees, it can be grown in varied soils, loam, sand and clay, but it prefers excellent drained moist soil with varied range of pH, alkaline, neutral and acidic.

Part II: Cultivation practices

Propagation:

The most popular methods propagation are grafting, budding and layering. Grafting methods includes whip-and-tongue graft, whip grafting, T-budding and chip budding. On the other hand, mound layering is used to propagate apple clonal rootstocks.

Soil preparation:

Before planting apple trees, the soil must be analysed, which is necessary to correct nutrient deficiencies and adjust soil pH. In order to keep the soil moist and nutritious, straw, hay or other organic matter must be applied to it. (https://www.almanac.com/plant/apples). All weeds must be removed before planting.

Planting:

In central and northern areas spring planting is recommended but in areas where autumn and winter weather is generally milder and moist fall planting can also be successful. To avoid the problems of deepening dormancy of the buds in the nursery as well as in the orchard, it is very important to use young shoots. The trees are planted at 3 x 2.5 m or in double rows, spacing (3.5 + 1.5) m x 2 m, giving densities of 1333 to 2000 trees per ha. Before planting, the roots are soaked in water for about 24 hours. If the roots are dry, a hole about twice the diameter of the root system and 2 m deep should be dug. Some of the loose soils are placed back in the hole and loosen the soil in the walls of the planting hole so that the roots can easily penetrate the soil. During planting, no fertilizer is required as the roots may "burned" (https://www.almanac.com/plant/apples).

Fertilization:

A common fertilization scheme used is adding once a year 0.5-2 kg N:P:K 12:12:12 or 11:15:15 per young tree and 3-5 kg N:P:K 12:12:12 or 11:15:15 per mature tree.

Irrigation:

The apple's water need is high, about 800 mm per year. The water use of the tree is divided to three periods. The first one starts from bud break and finishes when the tree fully developed is the increasing water use and the water use increases gradually. The second period is the main water use stage where the lack of water in this stage affects fruit development.

Disease control:

The saplings must be health free from any diseases, with known origins or with certificates. Replace chemical control with other methods when possible. Tools such as pruning tools must be clean and disinfected frequently. One idea to avoid pesticides is to select disease-resistant varieties such as 'Prima', 'Priscilla', 'Liberty', and 'Freedom'. They do not require spraying for apple scab, cedar-apple rust, and other common diseases, while most other varieties require periodic spraying every spring and summer after planting.

Other cultivation practices:

Training young and dwarf trees is very important to carry heavy apple crops. Standard (and semi-dwarf) trees should also be trained to a modified leader. Proper apple trees pruning practices increase the quality and value of the crop. Apple trees must be pruned every year. The amount and quality of fruits are determined by the relationship between vegetative and generative growths.

Harvesting:

Apples ripen satisfactorily on the tree. They should be picked when they have reached optimum size and color. The fruit tends to become mealy if overripe. Then, they cannot be stored more than two weeks even under refrigeration. The apple variety 'Anna' have been held under refrigeration satisfactorily for six to eight weeks.

Part III: post-harvest handling

Apples should be stored in the middle or end of the season. Mid-season varieties should be kept for a few weeks, while late-season varieties will stay in good condition for anywhere up to five months in a root cellar. Apples are stored by wrapping individual fruits in newspaper or tissue paper. Wrapped apples should be placed on trays that allow air to circulate. They can also be stored without packaging, but the fruit should not be touched. Different varieties are stored for different periods of time. The ideal storage is in a cool, dark and well-ventilated place. Most garages and sheds are ideal; while attics and basements should be avoided due to excessive heat, lack of ventilation or low humidity. Stored apples should be checked regularly, and any soft, brown or rotten ones removed.

Part IV: Utilization

Fruits, astringent taste, are used as laxative while infusion is used in treating bilious fever, sporadic. Some substances in leaves are known as antibacterial properties at low concentration, phloretin at 30 µg/ml prevents growing of gram positive and negative bacteria. Mature apple is convenient food for stomach while its juice decreases stomach acidity. Cooked and dried fruits may be preserved for later uses. Some verities fruits can be picked at July whereas others start at late fall season. Some cultivars produced pectin rich fruits that protect them from radiation. In addition, seeds are used in production of edible oil. When apples are used in the production of juice or cider vinegar their seeds are obtained and used for oil production.

3.1.9 *Olea europaea* (olives)

Part I: General aspects

Classification:

Latin name: *Olea europaea* belongs to Oleaceae family

Commonly known as olive (English), Olyf (Afrikaans), Umnquma (isiXhosa)

Figure 3.9 General morphology of Olive fruits

Origin and distribution:

Wild olives are native to Minor Asia (Bartolini et al., 2002). Olive trees (see also Figure 3.9) spread west through Greece, Italy, France, Spain, and Portugal following the coasts (Chiappetta and Muzzalupo 2012). Nowadays olive cultivations and selection of cultivars are expanding in many areas such as Australia and South and North America (Chiappetta and Muzzalupo 2012). In Europe of its six subspecies, only three are naturally distributed such as subsp. *europaea* in Greece, Italy, Spain, Portugal, France, Cyprus, Slovenia, and Malta as well as some Atlantic enclaves in South-West Europe; subsp. *guanchica* in the Canary Islands; and subsp. *cerasiformis* in the Madeira archipelago. Moreover, the other three, subsp. *maroccana* in Morocco, subsp. *laperrinei* in Sudan, Algeria and Niger, and subsp. *cuspidata* in South Africa throughout East Africa, Arabia to Southwest China.

Production levels:

There are reasons to keep a tree small, for example, to facilitate picking from the ground. Some mature trees which have not been pruned can reach 40-60 ft in height and produce up to 800 kg of olives while others only produce 50. For the same size tree, some varieties have more or larger olives.

The total area planted with olive trees is estimated at 8.1 million ha in 25 countries. The principal olive oil producing countries are Spain (32%), Italy (23%), Greece (14%), Turkey (8%), Tunisia (5%), Syria (5%), Morocco (3%), Egypt (2%), Portugal (2%) and Algeria (1%), which together account for 95% of the world supply. About 600,000 t per year reach the international vegetable oil market; the European Union and United States are the main importers of olive oil. The 1.1 million t of table olives produced annually represent about 8% of total olive fruit yields. Spain is the largest producer of table olives (25%) followed by the United States (14%), Turkey, Morocco, Syria, Greece, and Italy (6–9% each). In the Mediterranean Basin, table olives are sold in great variety by specialized sellers.

Mediterranean countries produce more than 70 % of the total world supply of olive oil. About 95 % of the European production is concentrated in Spain, Italy, and Greece. The leaves are used in medicine as a herbal tea, due to mainly their high phenolic compound content. Occasionally it is cultivated in gardens as an ornamental tree. The oleaster is a source of rootstock for propagating new improved cultivated varieties 2 ters a tree (https://uses.plantnet-project.org/en/Olea_europaea_(PROTA)).

Description of the plant:

The olive tree, *Olea europaea*, is an evergreen tree or shrub native to the Mediterranean, Asia, and Africa. It is short and squat, and infrequently exceeds 8–15 m (26–49 ft) in height. The silvery green leaves are oblong, measuring 4–10 cm long and 1–3 cm wide. The trunk is typically gnarled and twisted (Eddo et al., 2016). The small, white, feathery flowers, with ten-cleft calyx and corolla, two stamens, and bifid stigma, are borne generally on the previous year's wood, in racemes springing from the axils of the leaves. The fruit is a small drupe 1–2.5 cm long, thinner-fleshed and smaller in wild plants than in orchard cultivars. *Olea europaea* retains green over the year and it grows up to 10 m (32 ft) from 8 m (26 ft) slowly. It starts flowering at August and end it on September. Hermaphrodite species is considered monoecious, and its pollination carried out by wind, self-fertile plant.

Climatic requirements:

The Olive tree thrives in areas with Mediterranean climate, where mild winters are followed by sunny springs and hot summers. The areas where olive trees are cultivated for commercial use must have an average annual temperature of 15-20°C. The absolute maximum temperature can reach 40°C without causing damage, but the minimum should not fall below -7°C. Lower temperatures than this can cause serious damage to the trees. The temperature of -7°C is only indicative, because the resistance of the tree in cold depends on other factors, such as how quickly the temperature drops, the length of the frost, the presence of strong cold winds, humidity, germination and health of the tree variety, weather conditions before frost etc. So, the olive tree cannot be cultivated commercially in areas where the temperature often drops below -7°C. However, a certain amount of cold is necessary for the fruit set.

Soil requirements:

It is grown in vary medium, clay, loam, sandy and poor soils moist or dry one, but the preferable soil is the well-drained soil. It also can be grown in all pH types, neutral, alkaline and acidic and it may be considered as drought tolerant, while shade must be avoided (https://pfaf.org/user/Plant.aspx?LatinName=Olea+europaea).

Part II: Cultivation practices

Propagation:

The propagation of olive tree by seed is relatively easy. The propagation by seed is not recommended for commercial use. The olive tree is propagated by rooted suckers, cuttings and grafting. Professional olive farmers choose cuttings or grafts in order to achieve product uniformity and quality (https://wikifarmer.com/olive-tree-propagation).

Soil preparation:

The deep plowing of 20 inches (45-50 cm) aims to destroy perennial weeds and soil fluffing, which contributes to better development of the root system. In many cases, farmers add 20 to 30 t of manure per hectare (https://wikifarmer.com/olive-tree-soil-requirements/).

Planting:

The seedlings are concerned, farmers generally prefer those aged at least 2-3 years. Planting one-year seedings is likely to delay the first harvest. A suitable hole measuring 20 x 20 inches (50 x 50 cm) should be dug. Seedings should be planted at the same depth as those in the nursery. The surface soil of the pit must drop below the ball of the seedling. The planting of seedlings in areas where frost is not reported starts from late fall, while in areas with frost the planting starts in early spring, when even the last frosts have passed. The planting distances between trees 20 x 20 feet (6 x 6 meter) distance is frequently used (https://wikifarmer.com/planting-olive-trees/).

Fertilization:

The olive tree was suitable for poor and dry soils and could give medium yields on land considered unsuitable for other tree crops. A common olive tree fertilization scheme used by olive farmers involves adding 4-7 kg of N:P:K 11:15:15 fertilizer in every adult tree once or twice a year. The most suitable period is during fall and winter in non-irrigated trees. Fertilizer is added in the ground at a radius of 60-90 cm from the trunk, to avoid excessive concentration of a nutrient in one spot versus another. With no irrigation and no frequent rainfalls, farmers provide 10-20 t of manure per hectare every two years. Calcium levels are very important for a healthy olive tree as calcium reduces susceptibility to diseases. Calcium deficiency is often corrected by adding 6 – 7 kg of calcium oxide per mature tree (https://wikifarmer.com/olive-tree-fertilizer-requirements/).

Irrigation:

For successful cultivation the minimum average annual rainfall needed is about 600 mm. Olives can survive with 200–250 mm. Rainwater harvesting is an alternative to formal irrigation. Olive (*Olea europaea* L.) is considered drought-tolerant, and trees can survive on shallow soils with little supplemental water beyond winter rainfall (http://ucmanagedrought.ucdavis.edu/Agriculture/Crop_Irrigation_Strategies/Olives/).

In southern Portugal, mature drip-irrigated olive orchards with planting densities of around 300 trees per hectare ha require between 3500 and 4000 m^3 per hectare (350 to 400 mm) to satisfy irrigation needs for full irrigation (Pôças et al., 2014 and 2015). Applying irrigation depths smaller than those and at variable rates in distinct periods of the crop growth cycle (regulated deficit irrigation) has been advocated (Fernández, 2014; Fernández et al., 2013; Iniesta et al., 2009) to enhance water productivity.

Through olive first season of growing, 15-20 L of water is required for young tree. Investigation of climatic conditions at the second year, size of tree can help in detecting the water limits required for olive and making schedule of irrigation especially for ripe trees.

Diseases Control:

Olive attacked by two main fungi. Anthracnose caused high loose in olive fruit as leaves are injured by it and consequently the injury is also transferred to orchard and then restricted to others by the effect of air, as olive trees are cultivated intensively. On the other hand, olive is sensitive to soil-borne that attacked roots, which mostly produced with the less irrigation rate. In continued rainfall regions, fungal diseases will rapidly spread, therefore, practises applied for olive management should be suitable for controlling diseases especially fungi.

Other cultivation practices:

Olive orchard life term can be estimated depending on pruning, which must be kept at minimum limit the few primarily life years. Branches should be removed, which may prevent other branches growth that close to the soil. Organic mulch must be applied like manure of kraal or decomposed substances from sawdust of wood.

Harvesting:

House purposes Olive should be handled collected while tree shaker, mechanical harvest, is used for picking frames. First presence of purple blush or shiny pink or changing colour of fruit from green to yellowish colour refers to the plausible stage of fruits. Moreover, the fruit size should be taken into consideration in harvesting. In contrast, olive is picked in later times with complete black colour if the ripe black olive is required for processing harvesting time in black ripe oil should be accurate to avoid softening.

Part III Post Harvest Handling:

Picked olive must be transported immediately. Containers of underlying fruits are greater than containers used for transportation of table olives, and they should be paved with foam rubber to prevent fruit damage. After that, fruit should be classified into groups according to their size and then processed through 24 hrs to keep the quality of oil. Olive fruits with good character should be stored at 10°C for a limited time. Many producers of olives deliver the harvested fruits to processing in large quantities.

Part IV: Utilisation:

The fruit is edible, and all parts contain non-drying oil. Pickled, canned or otherwise prepared table olives are eaten as relish or used in bread, soups, salads, etc. The olive wood is heavy and very tough, used for high-end furniture, inlays, turned objects, and handcraft. It is also appreciated as firewood because it burns even when wet. The olive oil has several uses, for eating and cooking, as well as for ointment, lighting (burning without smoke), and medical uses. Olive oil is an important component of the Mediterranean diet, valued for its beneficial properties for human health, because of the high amounts of unsaturated fatty acids.

3.1.10 *Persea americana* (avocado)

Part I: General aspects

Classification:

Latin name: *Persea americana* belongs to Lauraceae family

Commonly known as; avocado, alligator pear in English; Aguacate, Palta in Spanish, vokado in Afrikaans.

Figure 3.10 General morphology of the avocado fruit

Origin and distribution:

Southern Mexico is considered as Avocado (see also Figure 3.10) origin, where it was cultivated in Rio Grande and extended to Peru in centre before arriving to Europe and then avocados were transferred to west of India and subtropical area. In addition, it is grown in United States commercially through tropical region of America and larger Caribbean islands. Philippines, Polynesia, Australia, New Zealand, Mauritius, Canary Island, Madagascar, tropical Africa, Algeria, south Spain, southern France, Israel, Sicily, Egypt, and Crete cultivated avocados successfully.

Production levels:

The main producing countries in the world are Mexico (36.8%), U.S.A (7.93%) and Colombia (5.56%). The other producing countries are Chile, Spain, Israel, South Africa, and Dominican Republic.

Description of the plant:

Avocados considered as intensive cultivated trees, retain green leaves through the year, shed lot of leaves in spring, fast growing tree, grow up to 24 m, branched to reproduce broad growth and the growth is regurgitated many times in warm conditions, whereas it has lonely long flush in cold conditions. Its leaves remained on the tree for two to three years, they are reciprocate, specular, oval and dark green.

Flowers of avocados start in January and continued to March. Greenish yellow blooms (200-300) are presented at the terminal panicles, one to three fruits can be produced from one panicle. Flowers are morning pollen sensual, afternoon shed pollen (A type), and afternoon sensual pollen as well as morning shed pollen (B type). The best production is obtained by cross-pollination by A and B types. Imperfect flowers percentage is about 5%.

Climatic requirements:

Cultivars of commercially avocados are suitable for cool and subtropical media accompanied with 20-25°C temperature range daily. Tree can tolerate light frost except the periods of flowering or setting fruits (August to September). The plausible temperature during flowering and setting fruits is more than 18°C. The most sensitive cultivars for cooling are Edranol >Hass > Pinkerton > Fuerte > Ryan. For mentioning, Fuerte cultivar requires temperature of 18°C but should be kept at at least 13°C.

Cultivars of avocado in South Africa are known as susceptible to drought. It is preferable to get water through dispensed rainfall (1000 mm) although most cultivars are considered to have flowering dry time. Therefore, water supplying is necessary in this time.

Soil requirements:

Darkened brown, red and brown to red soils are suitable for cultivation to keep logging of water, while rooting area mostly appeared in grey, light brown, white and yellow. Rich clay soils caused poor rooting, while large quantities of organic matter presented more acidic conditions and aluminium toxicity, which can be refined using calcification.

Mild clay content soils (20-40%) is preferred for avocado, while decreasing the percentage to less than 20% can cause decreasing in retention capacity of water, if suitable irrigation is applied trees will suffering from drought. In case of increased clay to more than 40%, trees should be ridge cultivated.

Perfect soil for avocados is fine cracking soil, which has less defined structure, whereas the highly thickened, prismatic internal structure, completely implausible.

Part II: Cultivation practices

Propagation:

Seed propagation can be applied for avocado that requires at least 6 years until fruiting though seedlings may require ten years to be bearing. The produced offspring is not typical for their parent in quality of fruits. From the above mentioning, rootstock grafting from seed propagated plants or layering plants is preferable for propagation.

Young rootstock, green house growing for one year, is ready to be grafted. Lateral grafting and terminal grafting are used usually, while scion cultivar needs six to twelve months more than that to be ready. Some cultivars are selected to be resistant or tolerant for diseases as soil-borne or infections.

Planting:

Plant spacing is applied according to cultivar habit and soil characters. In less heavy soils, the suitable distance is 7.5 x7.5 m, whereas in rich soil trees planted in maximum plant spacing (9.1 x 10.7 m) and trees grow to their maximum limit. Some producers used start cultivation with 3 x 4.5 m and then after succeeded in cultivation they remove other of them at seven to eight plant years old. In modern techniques vast spacing is suitable for mechanical processes. The hole of cultivation is 6 m in depth, well prepared and enriched with soil into hill. Young plants should beadded carefully, then weed must be controlled, and irrigation system should be applied. The topsoil should be moist using a dripping system, which is used as fertilizer supplier for 80% of tree requirements. For practical uses, some cultivars are grown much tall (9 m) and then top trees, whereas normally trees tall rich 4-5 m.

Fertilization:

Supplying trees with fertilizers starts after one growth year. Balanced fertilizers should be applied each quarter of year. In early summer and late winter, nitrogenous fertilizers should be applied to the old trees. In general, few amounts of fertilizers can be added every two months and they increased gradually up to starting fruiting. Trees in bearing required 1.5-2 kg added each four months and started at tree vegetation. In blooming, fertilizers must be avoided and wait up to fruit. Fertilization with nitrogen influenced vegetative growth, increase cold resistance, yield, and size of fruits. The deficiency of nutrient can be detected by leaf investigation and analysis, which mostly treated with foliar applications. For example, chlorosis is detected by the yellow colour of leaf and treated by foliar application of trace elements sprays containing iron, while ripe trees usually have zinc deficiency.

Irrigation:

In winter, avocado trees do not require irrigation, as rainfall is available whereas in midwinter trees should be observed for any requirements. The moisture of soil should also be detected at ending of irrigation time to avoid soil moist at the beginning of winter. In some cases, salts are tolerated by avocado. Even though, trees top observed in burning shape. Accumulation of salts can be avoided by deep irrigation especially in dry times.

Diseases and their control:

If the trunk of the tree is infected with *Botryosphaeria ribis*, *Dothiorella*, dead splashes will appear that continue to reach the ripe fruit and dark areas with stinky smell are produced. Mexican avocado trunk defends canker while fruits are sensitive. There is no method recommended for application as it depends on coast and spreading of infection. Wet conditions, that lead to foliage drop and root rot before the due time should be prevented. It is recommended to start watering the foliated plants after the root area has dried.

Trees defoliation causes injury with sunburn, sunscald. Young trees that grow in nursery with shading of bark, as well as trees that do not get the required water, may show an unhealthy root system exposed to sunburn. Providing good conditions in growing with appropriate water management can protect trees from sunburn.

Sun blotch is a viral disease that causes yellowed streaking of young stems, mottling, and crinkling of new leaves and occasional deformation of the fruit. It also causes rectangular cracking and checking of the trunk, as if sunburned. It is spread with the use of infected scions, contaminated tools and roots grafted with adjacent trees. It is important to use virus-free propagating wood.

Other cultivation practices:

Trees from columnar cultivar need to be pinched; this can be applied at young trees to form a circular shape. Other cultivars do not need pinching. Modern practices of gardens prevent hazards. It is preferable to fence trees with plastic mesh from the first year to three years, whereas dwarfed trees require steady staking. Sometimes, trees are refined to prohibit rodent, but it is usual to unrefine trees. Exposure of defoliated branches to sunlight can cause susceptibility to sunscald and lead to the die of the branches. Pruning must be avoided. Many cultivars are adapted to wattle.

Harvesting:

Avocado fruits remain tough on the tree, and they take their edible characteristics after picking. The edible mature avocado part is characterized by downy, buttery structure and their skin is not wrinkled, whereas skin of early picked fruits, unripe, is exhibited with wrinkles. The ripe fruit appears the biggest fruits. Picked completed grown fruit will reach ripen within one to two weeks, when they are kept at room temperature. When fully grown fruits remained on their trees will fall down causing fruit damage and may be broken that causes loss of yield. Nowadays, growers use short clippers for small distance harvests and long-arm clippers with metal rims for high branches to facilitate cutting of stems to catch targeted fruits. Gloves made of cotton can be used to keep hands and nails from scratching. The fruits are usually picked with a segment of stalk (10-15 mm) and then the good fruits should be transferred in canvas bags. The carrying bags should be cleaned to be free from any materials as sand. Each bag must contain 10-15 fruits. Pickers can use a ladder for picking and keeping the fruits undamaged.

Part III: Post harvest management

They are many instructions for post-harvest of avocado; labours in contact with fruits must wear cotton gloves. Fruits should be transferred one by one from bags and placed on trays. Durint the grading process, labours must be careful against contuse and the fruits should be graded according to their appearance. Fruits should be transferred from field soon after picking with careful. The transferred fruits should take their ways vastly either to markets or to storage under cooling during harvesting day. In addition, all tables used in avocado processing should be cleaned previously. Stems connected to fruits should be cut with a knife to a lenght of 6-12 mm. Fruits graded for export should have the same shape and then they are cured by fungicide and wax, as well as wrapping by cellophane and then arranged in boxes.

To keep fruits from fast ripping, fruits should be kept under cooling taking into consideration that very low temperature may cause hazards to fruits. In general, the best storage temperature is 5.5°C. Early ripe fruit can be stored at slightly higher temperature, whereas the late fruits can be stored under slightly lower temperature. To accelerate maturity of fruits, fruits can be exposed to ethylene at 10 µg/ml during 25-49 hrs of harvesting. If fruits are kept under refrigeration for long storage time of transportation, it may cause grey discoloration or dark brown coloration of mesocarp. The best temperature for avocado fruits is 4.5-12.8° for two weeks, while removal of storage will at 15.5°C.

Ethylene coulde be removed from the storage area using oxygen (2%) and carbon dioxide (10%) that leads to avocado marketable characters. Reduction of pressure to 60 mm Hg in the refrigerator with decreasing temperature to 6°C leads to maturation of avocado by decreasing respiration and production of ethylene; whereas avocado will ripen normally if it is stored at 14°C with normal atmospheric pressure. It was found that, treating avocado with calcium can delay maturity with decreasing inter relaxing injury, which exhibit implausible occurrence of fruits and lose their marketable characters. Treating fruits with fungicides during 24 hrs from harvest and sealing in polyethylene packages contained absorbent of ethylene as vermiculite, aluminium silicate or potassium permanganate can keep fruits for long period (40-50 days) at 10°C. Avocado covered by wax can be stored for two weeks below 5°C and matured below 20°C with one day later than non-waxed fruit; waxing decrease weight loss.

Part IV: Utilization

Avocado is used in preparation of table salad with dressing, or with sea food and cream cheese or as creamy dressing for fruit salad. Gelatin flavoured with lemon can be used with avocado after gelatin cooling. Avocado chunks are also often added to hot foods as chilli, soup, omelettes and stew.

Extracted oil from avocado is considered rich in many vitamins as A, B and E, which is used as dressing for hair and in making cream for face as well as lotions for hands. The remained pulp may be used in the preparation of stock feed.

The skin of avocado fruits is used as antibiotic and for treating dysentery. Leaves of avocado are used in many therapeutically applications like treating pyorrhoea whereas poultices of leaf is used as wound healing agent. Another use of the leaves is the treatment of neuralgia, after heating it, applied to the forehead.

Leaves aqueous extract can be used in treating hypertension, whereas decoction is used for treating diarrhoea haemorrhage and throat inflammation. It also regulates menstrual cycle and treats stomach-ache. Decoction of young shoots treat cough. Shoots or leaves obtained from purple-skinned type are boiled and the decoction is used an abortifacient.

Roasted seeds are used in treating diarrhoea and dysentery, while powdered seeds are used in treating dandruff. On the other hand, seeds piece or decoction of it is used as relieve for toothache, when it placed in mouth cavity. There is an ointment was made of pulverized seed and then it is used as face scrubber while skin eruption is treated by oil.

The milky fluid extracted from seeds has almond taste and flavour. This milky fluid turned from red to reddish brown colour that was used as ink for writing purposes in old Spanish. This ink has been used in linen textile and mark of cotton. The wood available from topped trees of tallest trees and thinned out of grooves is consumed in boards and turnery. Workers in Australia advice to use it in carving or for resembling of white beech as Eucalyptus wood, it appears beautiful when polishes. In addition, it is used for making jewel boxes. In favourable weather, honeybees combine high amount of pollen of avocado and the produced nectar became abundant, while it did not mix pollen with other sources, it produce thick and dark honey. Outside Latin America, avocado is commonly used as luxury fruit.

There are 2600 growers of avocado are members in Calavo growers in California while Mayflower association constitutes 60% of growers in San Joaquin Vally. Millions of dollars are spent for advertisment in magazinse, newspapers, radio, and television. Before 1972, about 8% of oil produced in California was exported by 1972, this became prohibited and discriminated. California cultivars have better characterisics as they have low calories with good flavor. Creation of information centre for avocado marketing was performed on 1983 in California. Israel makes substantial investments in developing European markets for avocados and has attained the position of the principal exporter to Europe. France and the United Kingdom are the chief consumers.

3.1.11 *Prunus dulcis* (almond)

Part I: General aspects

Classification:

Latin name: *Prunus dulcis* belongs to Rosaceae family

Commonly known as almond, sweet almond

Figure 3.11 General morphology of the almond tree and almond seed

Origin and distribution:

The cultivated sweet almond (*Prunus dulcis* Miller (D. A. Webb) syn. *P. amygdalus* Batsch, see also Figure 3.11) originated from the wild species known originally as Amygdalus communis L. which grew on the lower slopes of mountains in central Asia. About 30 related almond species have been described occupying specific ecological niches in the arid steppes, mountains, and deserts of central and south-western Asia and southern Europe. The geographical range of the cultivated almond corresponds to the three stages of cultural evolution: (1) Asiatic (south-west and central Asia); (2) Mediterranean (countries bordering both sides of the Mediterranean Sea); and (3) Californian (central valleys of California, parts of Australia, central Chile, and areas of South Africa). Almonds are adapted to Mediterranean, steppe, and desert climates characterized by mild, rainy winters and hot, dry summers. Although they have traditionally been grown with other arid tree and vine crops, such as olive, pistachio, and grape, almond trees respond so well to supplementary irrigation, fertilizers, good soil, disease, and insect control and other intensive culture methods that yields can be increased five- to 10-fold over the traditional culture practiced for centuries.

Production levels:

The world produced 2.00 million tonnes of almonds in 2011 according to Food and Agriculture Organization, with United States the largest producer at 0.73 million tonnes. The apparent 50% decrease in production by the United States led to a calculated percentage of world production decrease from 56% to 36%. In the United States, production is concentrated in California, with almonds being California's third-leading agricultural product, its top agricultural export in 2008, and 100% of the U.S. commercial supply. The United States is the dominant supplier of almonds. In 2011, the country exported about 637,000 metric tonnes, valued at US$2.8 billion. Almonds were mostly exported as shelled almonds (70%), with the remainder being either unshelled or processed. Australia is the largest almond production region in the Southern Hemisphere. In 2013, Australia contributed to 5.9% of the world almond supply. Most of the almond orchards are located in New South Wales, Victoria, and South Australia (Gibson and Herald, 2014)

Description of the plant:

The almond fruit is classed botanically as a drupe, with a pubescent exocarp (skin), a fleshy but thin mesocarp (hull), and a distinct hardened endocarp (shell). The mesocarp undergoes only limited enlargement during development, becoming dry and leathery, and dehiscing at maturity. The tree, while relatively slow in growth, can survive for 100 years or more, reaching heights exceeding 20 m. Almond's outlier status within the Prunus species has confounded its botanical classification. Presently, the most widely accepted scientific name, *Prunus dulcis*, acknowledges its taxonomic affinities with other Prunus based on similar morphology, molecular-genetic relatedness, and reported hybridization with peach, apricot, and some plums. Owing to the fact that it was first proposed in the literature, *Prunus dulcis* replaced the scientific name *Prunus amygdalus*, which still exists in European literature (Gradziel, 2009). In its Central Asian center of origin and diversity, the taxonomic experts most familiar with almond species in their native ecosystems have preferred to classify them in a separate genus, Amygdalus communis (Ladizinsky, 1999), arguing that their evolution of specialized botanical structures and development patterns in these often extreme environments justify a separate genus.

Climatic requirements:

Edible nuts are cultivated under a variety of growing conditions and climates; they are globally popular and valued for their sensory, nutritional, and health attributes (Venkatachalam and Shridhar, 2006). It is greatly spread through and well adapted to the whole Mediterranean region, from which about 28% of the world production is obtained. In fact, almond tree is an important crop, due to its fruits of high commercial value (Moure et al., 2007). Since almonds thrive in hot weather but cannot tolerate frost or high humidity, it is not surprising that almond cultivation spread in a narrow horizontal band westward through the Mediterranean to Spain, with the successive Greek, Roman, and Arab invasions (Ladizinsky, 1999).

Soil requirements:

As most fruit trees, it can grow in loam, clay and sand soils but it grows well in well-drained and moist soil with different pH limits, alkaline, acidic and neutral and it prefers sun.

Part II: Cultivation practices

Propagation:

Seedlings should be planted in separate pots when they grow enough. In first seedlings winter, they should grow in greenhouses or cold frames and then in late spring they can be planted out in the consecutive year. Semi mature wood is used for preparation of cuttings in July to August; whereas cuttings obtained from soften wood of strong plants should be prepared in spring or early summer. On the other hand, ripe wood cuttings are prepared in late fall, while layering is carried out in spring.

Planting:

Most almond cultivars are soft shelled; they are also self-incompatible, consequently plantations require the inter-planting of two rows of self-incompatible with a row of cross compatible cultivars;

Honey bees are required for pollination and are considered essential for the almond production. Trees in California begin to bear after 3-4 years and reach full productivity in ca. 7-8 years. Irrigation is favoured in California (Rosengarten, 1984)

Fertilization:

Careful attention must be paid to proper fertilization of the trees. Almond trees have high Nitrogen and Phosphorus requirements. Sandy soils are easy to cultivate and cover crops are comparatively easy to grow on them provided they are properly fertilized

Irrigation:

Although almond, being highly drought tolerant, has traditionally been associated with marginal rainfed areas, this crop under non-limiting conditions would offer significantly improved yield with a high economic return. In this context, in the San Joaquin Valley (California, USA), with irrigation rates of close to 12,000 m^3 ha^{-1} yr^{-1} , almond trees reach yields of up to 10 times higher than under rained conditions (Micke and Kester, 1978)

Disease control:

Prominent diseases include "shot hole" caused by Clasterosporium carpophilum (Lev.) Aderh., "white spongy rot" due to Fomes lividus K1, "brown patchy leaf rot" due to Phyllosticta prunicola (Spiz) Sacc., "brown rot" due to Sphaerotheca pannosa (Wallr.) Lev. and a mosaic disease due to virus plague almond (https://hort.purdue.edu/newcrop/duke_energy/Prunus_dulcis.html#Biotic%20Factors); (Petrov et al., 2011)

Harvesting:

Fruits occur mainly on shoot spurs, which remain productive up to five years. Bearing trees may be pruned of surplus branches to about 20% of the old-bearing wood. Tree exhibiting decline may be severely cut back at the top. In India, the trees bear from July to September. Fruits are harvested when the flesh splits open, exposing the stone. The flesh is then removed from the stones manually or by machine.

Manual harvesting of almond constitutes 25% of the total production costs because of the need to spend enormous amount of labor and time (Zabolestane, 2010). Mechanical harvesting is one way to reduce the costs. With continuous development in the almond plantation area and rising labor costs, the importance of mechanical harvesting becomes more evident than ever. Adrian & Fridley (1965) stated that harvesting by shaking the limbs and trunks is the most promising. The basic principle is to accelerate each fruit so that the inertia force developed will be greater than the bonding force between the fruit and the tree (Kepner et al., 1987). The excitation force is typically derived from cyclic oscillation of either a slider-crank mechanism or two opposite rotating eccentric masses connected to the tree to be harvested (Thomson, 1988).

Part III: Postharvest handling

At the factory the brown, outer, leathery coat (hull) is removed by blanching, which involves placing the almonds in contact with water at 82 °C for 3 minutes and either skinning by hand or by a special machine. The almonds are then dried to less than 8% moisture content and stored. Airtight containers must be used to prevent moisture pick-up. Although relatively resistant to rancidity, the almonds will deteriorate in time. On delivery to the packaging company, the almonds are shelled and graded. The grading process uses ultraviolet scanners for high-tech colour sorting to separate damaged and foreign matter before mechanical grading (Matz, 1984; Paramount Farms Almonds, 1991).

The basic quality requirements for almond kernels include: Style — whole kernels up to 1/8 broken off make up the bulk of international trade, but almond pieces, which may be sliced, slivered or diced, are also traded; Colour — natural or blanched; Absence of any foreign matter, insects, mould, rancidity, spots or blemishes; Taste and flavour; Maximum moisture content of 6.5%. Specific almond quality characteristics are defined by the following criteria:

The United Nations Economic Commission for Europe (UNECE) classification divides almonds into three main classes; Extra Class, Class I and Class II, depending on the presence of allowed defects; The most frequently used grading classification, also by UNECE, grades almond kernels by a minimum kernel diameter, or by the number of almond kernels per 100 gor ounce (28.3495 g).

There is no general rule for the size of the export packaging of almonds, but the most common size for European markets is 25 kg, although many traders accept imperial units and packages of 50 lb (22.68 kg). Other sizes also used include 5, 10 and 12.5 kg packages. Cartons are a common type of packaging, often with a plastic liner inside. Normally, a 20 ft container is fully loaded with 450 bags of 25 kg, while a 40 ft container is loaded with 880 bags of 25 kg (Exporting almond to Europe 2019). Almonds have a minimum storage life of 12 months, when they kept in proper conditions. Temperatures between 2° C and 7° C, at 50–60% relative humidity, offer optimal storage (Exporting almond to Europe 2019).

Part IV: Utilization

Almond has two main forms, bitter almond and sweet almond. The presence of cyanogenic glycoside is responsible for bitter taste. The bitter one is used in marzipan preparation and in flavour-industry but seeds must be avoided from consuming (the toxic dose for adults is 900 of sweet seeds).

There is a growing interest in dietary modifications to curb the global incidence and severity of complications related to obesity and type 2 diabetes. Recent studies have explored the acute effects of almond consumption on glucose, insulin, and gut hormone concentrations, with potential implications for chronic use. Additional work is also emerging on the bioaccessibility of almond components, and the fractions most responsible for their health effects (apsley and Mattes, 2011).

3.1.12 *Punica granatum* (pomegranate)

Part I: General aspects

Classification:

Latin name: *Punica granatum* belongs to Lythraceae family

Commonly known as pomegranate, dwarf pomegranate

Figure 3.12 General morphology of the pomegranate fruit

Origin and distribution:

Pomegranate (see also Figure 3.12) is one of the first domesticated fruits that have been cultivated from past times. It is indigenous to Iran and neighboring countries that gradually developed in central Asia regions to Himalaya, Eyalet of Anatolia, Middle East, and Mediterranean area. It also thrives in Arizona and California, and has been cultivated in the Mediterranean region, South Asia, and the Middle East countries; Kandahar in Afghanistan is famous for its high-quality pomegranate. Today, pomegranate is cultivated in most regions of the world, including Iran, Spain, Italy, Afghanistan, America, India, China, Russia, Uzbekistan, Morocco, and Greece.

Production levels:

The current total annual world production of pomegranate fruit is estimated to be around 1.5 million tonnes (Holland and Bar-Ya'akov 2008). India has occupied first position in the world with respect to pomegranate area (0.125 million ha) and production (1.140 million tonnes), but productivity-wise Spain holds prime position with 18.5 t/ha followed by the USA (18.3 t/ha). In terms of exports, Iran secured first rank with an annual export of 60,000 tons followed by India (35,176 t). Although, Spain has very little area (2,000 ha), its export share is 37.8% of total production (37,000 t) followed by Israel (23.5%) and the USA (15.5%). India has the lowest share (3.0%) with respect to export compared to other pomegranate-exporting countries.

Description of the plant:

Punica granatum is a small multi-stemmed shrub/tree 5-10 m tall. Canopy open, crown base low. Stem woody and spiny, bark smooth and dark grey. Leaves simple, 2-8 cm long, oblong or obovate, glabrous, oppositely placed, short-petioled surface shining. Flowers regular, solitary or in fascicles at apices, 4-6 cm. Petals lanceolate, 5-7, wrinkled and brilliant orange-red. Hypanthium coloured, 5- 8 lobed. Anthers numerous. Calyx persistent. Fruit a round berry, 5-12 cm, pericarp leathery. Interior compartmentalized with many pink-red sections of pulp-like tissue; each contains a seed grain. Fruits globose with persistent callipe and a coriaceous woody rind and seeds numerous, angular with fleshy testa, 1.3 cm long.

Climatic requirements:

The pomegranate plant is very adaptable and will grow in regions ranging from temperate to tropical. It is deciduous or semi-deciduous depending on its location. The best prospects for commercial fruit production exist in those parts of the State, where the summer is warm to hot and where rainfall is minimal during late summer/autumn (Agfact, 1983).

Soil requirements:

The pomegranate growing regions of the world have observed that it grows in heavy clay, clay loam, chestnut, loamy, loamy-pebble soils, sandy loam soils rich with humus, black earth (chernozem), light humus soils with pebble inclusions, yellow soils (zheltozen), on podzolclay, alluvial soils, on seaside sands, gravel talus dry rocky hills, alkali soils, lime-rich soils as well as on limestone rich lands of arid hills. However, the best soils for pomegranate cultivation are fertile, rich with humus, deep, medium density with good drainage and especially alluvial soils. And such soils produce the best quality fruits. Even it can be grown well in slightly saline soils as it is considered a saline-tolerant plant (Patil and Waghmare, 1983; Rao and Khandelwal, 2001; Ram et al., 2002).

Part II: cultivation practices

Propagation:

Pomegranate plants can be propagated either sexually by seeds or asexually by stem cuttings, layering, bottom sprouts and grafting (Polat and Caliskan, 2009). Tissue culture is another method of production that calls for the growth of the plant in a sterile environment using the tissue, seed, or cuttings (Abdelrahman and AI-Wasel, 1999). Seed-raised plants show a great variability with regard to tree vigour, precocity and quality of fruits. Therefore, vegetative propagation is utmost desirable to propagate true to type plants (Kaur and Kaur, 2016).

Soil preparation:

Land is prepared by ploughing, harrowing, levelling and removing weeds.

Planting:

Density of planting depends on temperature. At North India, it is cultivated with spacing 5-6 m. Low plant spacing produces two to three times of yield presented by normal spacing cultivation (5 x f5 m), while farmers prefer cultivation with 2.5 x 4.5 plant spacing. In dense plants, the incidence of disease increases. Commonly, growers used square system taking into account the transmission of light is recommended by a lot of light.

A hole (60 x 60 x 60 cm) at spacing 5 cm in square system should be dug one month before planting and be exposed to sun. Fifty g of 5% BHC or carbaryl dust id spreaded at the bottom and sides to face termites. These holes will then be filled with soil mixed with 20 kg farmyard manure and 1kg superphosphate and then should be watered to allow soil to settle down. After that, cutting may be planted and irrigation can be applied.

Fertilization:

Generally, 2 to 4-ounce of ammonium sulfate or other nitrogen fertilizers are applied to the trees during the first two springs. After that very little fertilizer is needed, although the plants respond to an annual mulch of rotted manure or other compost (Kumari et al., 2012).

It has been reported that to get 30 t fruit yield/ha in 'Ganesh', 33.6 kg N, 6 kg P, 52.2 kg K, 13.6 kg Ca, 2.0 kg Mg and 4.4 kg S, 55 g Fe, 28.5 g Mn, 78 g Zn and 38.8 g Cu are removed (Raghupathi and Bhargava, 1996). Thus, replenishment of nutrients in soil is of para-mount importance. Raghupathi and Bhargava (1998) noted that yield of pomegranate was limited by 2 or 3 nutrients, as it is mainly grown on marginal soils having low fertility.

Farmyard manure (10 kg/tree/year) is recommended for fertilization as well as 600-700g of nitrogen, 200-250 g of K_2O and 200-250 g of P_2O_5 per plant yearly. After five years, ammonium sulphate should be added (75 g/tree) and followed yearly. At the flowering stage, application of 1 kg ammonium sulphate and 3.5 kg of oil cake is required for healthy growth and fruiting. December to January is the best time of addition for ambe bahar, while May to June is suitable for Mirg bahar and October to November for the hasthe bahar. On the other hand, the basal dose of farmyard manure is 25-40 cart-loads /ha is preferable to be added with the previous fertilizer regime for non-bearing trees in 3 split doses coinciding with growth of flushes during January, June and September. To encourage fruiting, nitrogen source should be applied in two split doses starting at the time of first irrigation after bahar treatment and next at 3 weeks interval, whereas full dose of P and K should be applied at one time. The addition should be applied in a shallow circular trench below tree canopy not beyond a depth of 8-10 cm and followed with irrigation.

Irrigation:

Once established, pomegranates can withstand considerable drought, but for good fruit production they must be irrigated. To establish new plants, they should be watered every 2 to 4 weeks during the dry season. The plants are tolerant of moderate saline water and soil conditions. (Kumari et al., 2012)

Diseases control:

This tree is commonly growing without pest and disease infection. Sometimes it may face minor problems as spotting of fruit or leaves, which is presented by the white fly, mealy and thrips. Application of Mancozeb (2 g/L) during rainy season in case of the former and application of Kavach (2 g/L) and Carbendazim/Thiophanate methyl/Baycor/Benomyl (1 g/L) during September/October in case of the latter considered promising for treating spotting of leaves and fruit rot.

Other cultivation practices:

Single stem trained plants are considered sensitive to pests viz., whereas other systems are less susceptible. Pruning is not much required except for removal of ground suckers, water shoots, cross branches, dead and diseased twigs gaining the shape of tree. For encouraging growth, a little thinning and pruning of old spurs is done.

Harvesting:

The fruits are ripe when they have developed a distinctive colour and make a metallic sound when tapped. The fruits must be picked before over maturity when they tend to crack open, particularly when rained on. Pomegranate can withstand long-term storage. The optimum temperature for storage is 0-5°C to keep fruits for seven months with relative humidity of 80-85% and fruits will remained have marketable characters without spoiling or wrinkles. Storage enhances fruit characters as they became juicier than before and more favourable (Kumari, 2012).

Part III: Post-harvest handling

Pomegranate commercial life means the time that this fruit can keep a certain quality level under specific storage conditions. The physiological status and development of the fruit play an important role in the refrigerated storage and handling processes, aiming to minimize the quality loss. As a non-climacteric fruit, pomegranate does not ripen after harvest, and for this reason it has to be harvested when is fully ripened, when it shows the optimal organoleptic characteristics. In pomegranates, the more intense the respiration, the faster is the decay. Temperature, relative humidity and atmosphere composition, are the environmental factors that, depending on the desired storage period, can be used to reduce the respiration and 130ptimizi the physiological and fungal decay losses (Ben-Arie et.al., 1984; Kader, 1984).

It is evident that one of the main ways to extend the post-harvest life of pomegranates is reducing as much as possible the mechanical damage (bruises, scrapes, cuts, compression, etc.), with a careful handling. Another essential way to prolong the commercial life of pomegranates is 131ptimizing the environmental conditions that will maintain the quality specifications of the fruits within economic margins. Many studies have demonstrated that temperature is the most important factor to control the respiratory activity, transpiration and the development of microbial pathogens. A fast pre-refrigeration using forced air is one of the simplest ways to extend pomegranate commercial life. This temperature has to be around 5°C to prevent the production of physiological disorders, during 2-3 months storage (Kader, 1984; Artés, 1992).

The relative humidity is the second factor in importance. The key concept is the deficit in vapour pressure or difference between relative humidity of the environment. Temperature and relative humidity are closely related, and the objective is minimising the weight loss without increasing the microbial development and decay. As pomegranates are commercialised without post-harvest treatments (washing, waxing, fungicides), the fruits must be gently brushed, and kept with a relative humidity around 90-95%, if the fruits are healthy and clean (Artés, 1992).

Recommended temperatures to store pomegranate have varied from 0 to 10˚C, with a storage life ranging from 2 weeks to 7 months depending on the cultivar (Kader et al., 1984)

Among physical characteristics, dimensions, mass, volume, and projected areas are important parameters in sizing and grading systems. Fruits with the similar weight and uniform shape are desirable in terms of marketing value. Therefore, grading fruit based on weight reduces packing and handling costs and also provides suitable packing patterns. The different grading systems require different fruit sizing based on particular parameters (Khoshnam et al., 2007).

Part IV: Utilization

Punica granatum have been used in folk medicine for centuries in the Middle East, India, and China, and it has been used to treat ailments ranging from inflammation and rheumatism to the pain of a simple sore throat. The most famous usage worldwide has been as a vermifugal or taenicidal agent (Zhicen, 1978; Kapoor, 1990) i.e., a killer and expeller of intestinal worms. The pericarp is used by Chinese and South Africans for the treatment of diarrhea, metrorrhagia, metrostaxia, and bellyachea. In Unani medicine its flower is used as a food supplement to treat diabetes mellitus.

Different part of pomegranate like bark, leaves, immature fruits, and fruit rind have some medicinal significance. According to Satomi et al. (1993), the pericarps of Punica granutam contains seven highly active inhibitors of carbonic anhydrase (CA) i.e., punicalin, punicalagin, granatin B, gallagyldilactone, punicalagin, pedunculagin and tellimagrandin. The four weakly active inhibitors, gallic acid, granatin A, corilagin and ellagic acid, are known to exhibit antimicrobial, antifungal, antimutagenic activity, (Punicaceae) and are term as ellagitannins. The type of inhibition by punicalin and punicalagin against pnitrophenyl acetate as a substrate is found to be noncompetitive (Satomi et al., 1993). Other traditional uses of these materials have included treatments for snakebite (1984), diabetes (Singh YN, 1986) , burns (Siang ST1983) and leprosy (Singh VP, 1980). The fresh fruit itself has been used as a refrigerant to lower fever (Arseculeratne et al., 1985).

3.1.13 Prunus avium L. (sweet cherry)

Part I: General aspects

Figure 3.13. General morphology of prunus avium

Classification:
Family Rosaceae – rose family
Genus Prunus L. – plum
Species Prunus avium (L.) L. – sweet cherry, wild cherry

Origin and distribution:

The origin of wild cherry (see also Figure 3.13) is Europe, northern Africa, and southwestern Asia. Also, it is widely distributed at many regions and is naturalized in North America and Australia (Welk et al., 2016).

Production levels:

According to the FAOSTAT, 2018, Turkey is the largest producer for cherries all over the world and its productivity is about 639,564 tonnes, it followed by USA, Uzbekistan, Chile and Iran. The global production of cherries is 2.54 million tonnes. Europe produces 33.9 % followed by America, which produces 19.9% of world production.

Major Production areas in South Africa:

In South Africa, cherries are cultivated mainly in the Western Cape, province with 50% of the cultivated area in the country, followed by the Free State province with 34% (Voigt, 2019). The area cultivated with cherries is about 262 hectares, which is mainly cultivated by Bing, Royal Dawn, Royal Lee, Sweet Heart, and Early Sweet cultivars (Voigt, 2019).

Description of the plant:

The wild cherry is a medium-sized deciduous tree. It reaches a height of 15 - 32 m and a diameter of about 90 - 120 cm. The leaves are alternate, simply with slightly serrated margins. The color of the leaves changes from light green in spring to dark green in summer and yellow, orange-red, red or pink in autumn. The young trees grow with a straight trunk and an upright pyramidal shape. The flowers are white, hermaphroditic and are pollinated by insects (bees) placed in an inflorescence of 2-6 flowers. The fruit is 1-2 cm in diameter, its color is red to dark purple and each fruit contains a seed with a hard stone shell (Welk et al., 2016).

Climatic requirements:
Wild cherry does not prefer very hot summers or winters with high temperatures for short periods. Most cherry varieties need at least 1000 hours as cooling requirements during the winter (Long and Kaiser, 2013). The plant prefers to grow at 300-900 m above the sea level. Regardless of the temperature, turmeric thrives at 18.2 - 27.4 ° C, this range is optimal for its growth, while the plant needs at least 700 mm of annual precipitations (Coello et al., 2013; Long and Kaiser, 2013; Verma, 2014). In addition, rain, heavy fog or dew before harvest lead to to cracking of the cherries.

Soil requirements:

Wild cherry can grow in a wide range of soils, but the soil suitable for wild cherry crops is well-drained clay soil with a pH range of 6.2-6.8 and a soil depth of at least 3 feet (Verma, 2014).

Part II: Cultivation practices

Propagation:

Commercially, cherry trees are propagated by budding and grafting of the desired varieties on the rootstocks. Mainly, Mahaleb (*Prunus mahaleb*) or Mazzard *(Prunus avium*) is used as rootstocks for propagation of sweet cherries varieties. Mahaleb is 20% more dwarf compared to Mazzard (Verma, 2014).

Soil preparation:

Sweet cherries are sensitive to excessive moisture, as they can be infected by a soil-borne fungus such as Phytophthora, which causes crown rot. Accordingly, it is preferable to grow sweet cherries in well-drained soils, as well as trees can be transplanted into raised beds.

The soil must be deep enough to allow adequate root growth. The soil must be ploughed to a depth of 1-1.5 m to break the hard layer (Hardpans). Hard stones and rocks should be removed. The dimensions of the holes should be approximately equal to 0.5 m wide and 0.5 m deep. The dug soil can be mixed with compost and placed back in the holes, then sweet cherry transplants are cultivated (Verma, 2014).

Planting:

Planting can take place during plant dormancy, usually between November and March. According to the rootstock used, the planting distance is determined. Sweet cherries in vigorous root stocks can be planted 6-7 m between rows and 4-5 within row, while dwarfing rootstocks can be planted with plants 5-6 m between rows and 3-4 within row (Verma, 2014).

Fertilization:

To calculate the amounts of nutrients that plants need, soil and leaf analysis is usually performed. After planting, the transplants are fertilized twice; the first is after transplanting by 2 weeks, and the second after 6 weeks after transplanting. Typically, nitrogen is the nutrient used in plant fertilization after cultivation at a rate of 25 g per tree for nitrogen in each dose. Also, preferred is 10-10-10 or 5-10-10 (Verma, 2014). Fertilization rate ranges from 25 g to 45 g N / tree / year until the trees are about 8 years old, then the fertilization rate increases in mature trees to 275- 450 g N / year, also complete fertilizer such as 10-10-10 or 5-10-10 can be used to provide these nutrients. Fertilizers can be divided throughout the season or can be applied one month before flowering.

Irrigation:

Sweet cherries are sensitive to excessive moisture, as they can be infected by a soil-borne fungus such as Phytophthora, which causes crown rot. In terms of water needs, the wild cherry plant needs an annual precipitation of at least 700 mm, while an additional irrigation should be applied to supply the plants with its requirements. In addition, water stagnation must be avoided (Coello et al., 2013; Verma, 2014)

Disease control:

Wild cherry plant is susceptible for many fungal and bacterial diseases. The bacteria *Pseudomonas syringae* pv. *syringae* and *Pseudomonas syringae* pv. *morsprunorum* cause bacterial canker in wild cherry. It enters from wounds, pruning cuts, or winter injury sites and natural openings such as stomata and causes canker. Bacterial canker is controlled by applying 1 to 2 applications of Bordeaux mixture before bud break.). Concerning the fungal diseases, *Phytophthora* crown is one of the most common fungal diseases that infect wild cherry trees; it is caused by *Phytophthora* species. Fungi can be spread by irrigation water. The Infected trees do not exhibit terminal growth; leaves may be small and yellowed. These trees frequently bloom profusely. Death may occur during the year of initial infection or several years later. Smaller trees die more quickly. Its symptoms are the production of a gummy substance that appears on the trunk, making it difficult to distinguish the disease from bacterial canker, Mahaleb is very sensitive. Moreover, there are other bacterial diseases that infect the wild cherry trees such as crown gall caused by *Agrobacterium tumefaciens,* and fungal diseases such as such as brown rot caused by *Monilinia laxa* and *Monilinia fructicola* and cherry leaf spot caused by *Coccomyces hiemalis*.

Harvesting:

Usually, sweet cherries are harvested manually using scissors to cut the stalks or by hand picking, but without avoiding the injury of the shoots. The fruits are harvested after full ripening (dark red, black, and yellow) because cherries will not ripen once removed from the tree (Kaack, 2017; Grant, 2020)

Part III: Postharvest handling

After harvesting the cherries are transferred to the packinghouse, where various work take place. Initially, the cluster cutting function is usually applied in order to distribute the cherries by size. Then, the cherries are sorted to remove the damaged fruit. This is usually followed by water cooling of the fruit and packaging of the fruit. Optimal storage conditions are -0.5 ± 0.5 ° C and 90-95% humidity for 2-3 weeks, as high humidity is particularly important for maintaining the green color of the stem (Crisosto et al., 1996).

Part IV: Utilization

For many years, wild cherry fruits have been consumed by humans; sweet cherries are eaten in jams, jellies, beverages or used as a flavoring. It is also used to treat cancer, heart disease and osteoarthritis (WebMD). In addition, the cherry tree produces very high-quality timber with valuable solid and dense wood that can be used for parquet floors, for making musical instruments and for producing veneer. In addition, wild cherries can be used as an ornamental landscape model (Coello et al., 2013; Welk et al., 2016).

3.2 Non-edible Trees

3.2.1 Albizia julibrissin Durazz. (mimosa)

Part I: General aspects

Classification:
Family Fabaceae–family
Genus Albizia L. – albizia
Species Albizia julibrissin Durazz. – mimosa. silktree, Persian silk tree, silky acacia

Figure 3.14.General morphology of mimosa tree

Origin and distribution:

The origin of the mimosa tree (see also Figure 3.14) is the Southwestern and eastern of Asia, Also, it is widely distributed in many regions such as Europe, Africa and the Americas (Meyer, 2010).

Production levels:

The mimosa trees produce about 8000 seed/year. The tree produces many flower heads every year. Major Production areas in South Africa: In South Africa, silk tree is introduced and cultivated (CABI, 2019).

Description of the plant:

Silk tree is a deciduous tree that ranges 6 – 12 m height, it has a straight trunk but in nature the tree grows with multiple trunks. The tree has a wide canopy. The leaves arrangement is alternate. The leaf is about 20 -30 cm long. The leaf is bipinnate compound, with 6-12 pairs of leaflets, each divided into 20-30 pairs of ultimate segments, 1 cm long, light green and oblong. The flowers are light pink, carried in terminal clusters of dense heads, each terminating in a stalk; each head has 15 to 25 sessile flowers. The fruit is flat legume which has brown color and 15 cm long, constricted between the seeds, which remains on the plant until the next spring. Seeds have hard and impermeable coat, and can remain dormant for years. The plant is monoecious, and the flowers are self-incompatible which are pollinated by insects (Meyer, 2010; CABI, 2019). The tree can fix the nitrogen in the soil since it makes symbiosis with *Rhizobium* sp. (Himmat Singh and Pokhriyal, 1999)

Climatic requirements:

Silk tree is distributed in the northern hemisphere; it can be found at 42 ˚N to 10 ˚S. It grows well in full sunny conditions (Gilman and Watson, 1993). Concerning the altitude, the plant can grow at 2100 m above the sea level (CABI, 2019).

The lower critical temperature degree it can tolerate is 23 ˚C, while the mean annual temperature is 9 ˚C for the lower and 28 ˚C for the high temperature degree. Concerning the annual precipitations, the silk tree can grow at lower limit 100 mm, while the high limit is 2300 mm (**CABI, 2019)**.

Soil requirements:

Silk tree plant can grow at a wide range of soils, clay, sand, loam. It can fix the nitrogen by the symbiotic relation with *Rhizobium* sp. so it can grow in poor soils. It grows at acidic to moderately alkaline soils with a pH range 5.67 - 7.94 (Meyer, 2010; CABI, 2019). It is high tolerance to drought and low tolerance to salinity (Gilman and Watson, 1993).

Part II: Cultivation practices

Propagation:

Commercially, mimosa trees can be propagated by seeds. The seeds are soaked for 24 hours in hot water and then cultivated in greenhouses in March and April also scarification application for the seeds helps in the germination. The germination lasts about 2-3 months at 19 ° C. Then, the plants can be transplanted into individual pots with rich soil. In addition, cuttings of half-ripe wood can be used for propagation in July and August.

Soil preparation:

Soil tillage improves the soil conditions. Soil must be deep enough to permit adequate root development. The soil must be ploughed deeply up to 1-1.5 m to break up the hard layer (Hardpans). After removing rocks and break up the soil clumps, the trees locations are localized in the land

Planting:

For the cultivation of mimosa, the planting of seeds must not be deep; the depth should not be more than 2 cm in loose moist soil at fully sunlight conditions. Mimosa is used as a beautiful ornamental tree that can be used as a shade and roadside tree due to its resistance to air pollution (PFAF).

Fertilization:

In order to calculate the nutrient quantities that the plants need, soil and leaf analysis must be performed. The silk tree can fix the nitrogen to a form that is available to the plant. The high fertilization rates and the high fertile soils can promote soft sappy growth, which is frost tender (PFAF). Fertilizing the trees with compost or organic fertilizers is preferable in early spring before the buds break and the leaves grow (Patterson, 2020).

Irrigation:

The Persian silk tree can grow in a wide range of water supply, the annual lower critical precipitations is 100 mm, while the highest precipitation is about 2300 mm. In general, the trees need just enough water to keep moist; also it tolerates a short period of drought (Patterson, 2020).

Disease control:

Mimosa trees are infected by *Fusarium oxysporum,* which cause the fusarium wilt, its symptoms are wilted and dried foliage and defoliation of branched, the branches and the trunk can exhibit gummosis, and internally the wood may show brown to black streaks of discoloration that spread in the branches downward to the roots (Nesbitt et al., 1999; Bush, 2008). It can be controlled by planting the trees in well-drained soils and avoiding excessive watering of the plants, in order not to fertilize the trees with excess fertilizers, it is preferable to solarize the soil to kill the pathogens before cultivation (Gowans, 2020). Gilman and Watson (1993) mentioned that the fusarium wilt is a fatal disease to the mimosa tree.

The mimosa tree can be infected by many pests such as cottony cushion scale, mites, mimosa webworm. It can be controlled by spraying appropriate pesticides.

Harvesting:

Many parts of the mimosa tree plant are used as food by human or used to make medicine. Young leaves and flower heads can be consumed by humans. The leaves can be gathered at the desirable stage; also, the flower heads are collected after blooming. In addition, the tree bark is used to make medicine and it can be peeled and collected.

Part III: Utilization

Albizia julibrissin Durazz. Is a beautiful ornamental plant that can be used as a shade and roadside tree since it resists air pollution. It can also preserve the soil, as it can prevent erosion because it has a wide and large root system. It can be grown as a bonsai model. The leaves provide a useful soil conditioner and modification when incorporated or applied as mulch (PFAF). Also, the wood of the silk tree is dense and hard that is polished and used for making furniture. The young leaves are cooked and used as potherb, while flowers are cooked and eaten as vegetables. Dried leaves are used as a tea substitute (PFAF).

In China, the flower heads are used as carminative, digestive, sedative, and tonic. Also, it is used in treating insomnia, irritability and breathlessness. Moreover, the bark is anthelmintic, carminative, diuretic, sedative and vermifuge. A gummy extract that can be obtained from the plant is used as a plaster for abscesses and also as a retentive in fractures and sprains (PFAF, 1999).

There are other uses for the plant parts, the bark has been used as an insect repellent, and as medicine; it is used to treat insect bites, skin infections (boils and abscesses), ulcers, fractures, and sprains. (WebMD). In addition, Web MD electronic site mentioned that there are other uses to the mimosa plant; it is taken by mouth for anxiety, cancer, depression, sore throat; to improve mood; and to reduce swelling associated with trauma.

3.2.2 Betula pendula (silver birch)

Part I: General aspects

Classification:

Scientific name: *Betula pendula*

Common names: silver birch, warty birch, European white birch, or East Asian white birch

Family: Betulaceae

Figure 3.15 General morphology of the silver birch tree and its leaves

Origin and distribution:

The silver birch (see also Figure 3.15) grows naturally from west of Europe eastwards to Kazakhstan, Siberia, Mongolia, and the Xinjiang province in China, and southwards to the mountains of the Caucasus and northern Iran, Iraq, and Turkey. It is also native to northern Africa (Morocco) and has become naturalized in some other parts of the world (USDA, 2019 b). Its tolerance to pollution makes it suitable for planting in industrial areas and exposed sites. It has been introduced into North America, where it is known as the European white birch, and is considered invasive in the states of Kentucky, Maryland, Washington, and Wisconsin. It is naturalized and locally invasive in parts of Canada.

Production levels:

The birch volume of the growing stock differs according to the country, it was 11023 Mm^3 in Russia, 357 Mm^3 in Finland and 334 Mm^3 in Sweden (FAO, 2010). Also, in naturally regenerated pure unmanaged birch stands up to the age of 80 years the cumulative volume yield varies between 320 and 540 m^3/ha which corresponds the mean annual increment between 4 and 6.75 m^3/ha (Hynynenet et al., 2010).

However, currently the composition of this species and its economic significance is high only in Northern and North-eastern Europe. For example, birch composition in Finland and Norway is about 16%, in Estonia it ranges between 20–30%, and in France or Czech Republic it is under 3% of the total volume (Hynynen et al., 2010; Kula, 2011).

The European birch trees are not growing in the southern Africa countries, but it found in the northern countries of Africa (Morocco).

Description of the plant:

Silver birch is a deciduous tree 15 to 25 m tall, and it reaches up to 30 m, with trunk diameter usually under 40 cm. The bark of young trees is brown in colour and it turn to silvery-white at maturity, with horizontal dark grey lenticels. The tree branches characteristically droop, while the leaves are coarsely, unequally double-serrated and 3-7 cm long (Beck et al., 2016). The flowers are catkins and the light, winged seeds get widely scattered by the wind.

Climatic requirements:

European birch trees need cool climate at least for the occasional winter snowfall. As they are shallow-rooted, they may require water during dry periods. They grow best in full sun planted in deep, well-drained soil (Botanica, 1999).

Soil requirements:

It prefers dry or moist soil. The plant can tolerate strong winds but not maritime exposure.

Most fruit trees prefer well-drained soil but can grow in varied types as loam, clay and sandy soils. In addition, it can be planted in rich clay soil and poor soil with suitable fertilizer regimes. Considering pH range, it can grow in neutral, acidic and alkali soils also grow in high acidic soil. Moist and dry soil can be planted. It tolerates winds but not to expose to maritime (https://pfaf.org/user/Plant.aspx?LatinName=Betula+pendula).

Part II: Cultivation practices

Propagation:

Mainly it can be propagated by seeds that are collected at late summer and sown at summer (Germination temperature 21-29°C). Softwood cuttings (Stem tip) can be used for propagation and the cuttings are taken at early summer (IFAS, 2018) electronic site.

Birch can be propagated vegetative, i.e., cloned, by grafting, rooting or by means of tissue culture. Production of grafts is quite expensive, and grafts are used mainly for clonal collections and seed orchards (Ryynänen 1987). Also, rooting of birch cuttings is not much used in birch propagation as the percentage of rooted cuttings is low (10-50 %) for *B. pendula*, whereas Kling et al. (1985) found rooting rates of 80 % for a closely-related *B. platyfylla*.

Planting:

The silver birch tree is planted decoratively in parks and gardens also can be used as specimen plant or in borders. In addition, it is used for forest products such as joinery timber, firewood, tanning, racecourse jumps, and brooms. The winged fruits are efficiently distributed by wind, so it is considered as the method of spreading and planting new plants (Natural regeneration) at forests (Beck et al., 2016). In addition, planting is usually the preferred method, if production of high-quality timber is the goal (Hynynen et al., 2009). Stem sprouts can be used as a regeneration method in intensive short-rotation management. Moreover, planting is the most certain and the most expensive method to establish a pure even-aged birch stand. Planted seedlings are more competitive against the ground vegetation than naturally regenerated seedlings. In planting, container grown seedlings are used with a planting density of 1600 seedlings/ha, which is considered to be the maximum number of silver birch trees per hectare that can reach the merchantable stem size. Then pre-commercial thinning is recommended in young birch stands with high densities. In Northern Europe, the recommended spacing for a birch stand after pre-commercial thinning varies 1600 to 2500 stems/ha (Cameron et al., 1995).

Bare-root trees should be planted between November and March, and container-grown ones any time of year, but preferably in autumn, winter or spring. The hole should be 60 x 60 cm (2 x 2 ft) and 30 cm (12 in) deep. A layer of organic matter should be added – such as compost or well-rotted manure – to the base of the hole and dig in. The roots are placed in the planting hole and the planting depth is adjusted so that the tree is planted at the same depth as the initially growing one and the top of the roots are level with the soil surface.

Then organic matter should be mixed with the excavated soil and the planting hole should be filled. The tree should be wagged with a rigid tree and two tree ties so that it is fully supported by the prevailing winds. Then, it should be watered very well and a granular general feed above the ground around the tree should be applied and 5-7.5 cm (2-3 in) deep rotten well rotten garden compost or bark should be added around the root area. The tree should be well watered while growing. (https://www.lovethegarden.com/uk-en/article/silver-birch-betula)

Fertilization:

Silver birch tree plants roots are easily associated with a large number of ecto-mycorrhizal fungi. Fertilization is not a common practice in the management of birch stands. A few empirical fertilization trials in Finland have shown only a weak growth response to fertilization (Beck et al., 2016).

In general, B. pendula is a nitrogen-limited species. Low-nitrogen conditions reduce growth and increase amount of condensed tannins, whereas in high nitrogen conditions B. pendula grows faster and the content of flavonoids in foliage is higher (Keinänen et al., 1999). The effects of nitrogen fertilization on herbivore resistance are not clear. Nitrogen fertilization does not affect preference of mammalian herbivores on *B. pendula* seedlings. On the other hand, the autumnal moth grows larger on fertilized seedlings (Mutikainen et al., 2000). The limiting effects of other nutrients on the birches are not as well defined. At optimum levels, both zinc and manganese stimulate seedling growth, but toxicity problems have also been reported. There is a wide genetic variation in zinc tolerance and uptake. *B. pendula* has a high requirement for sulphur, and it readily takes up boron. It sometimes suffers from manganese toxicity on poorly drained peat. The pH optimum for B. pendula and B. pubescens is between 4 and 5. B. pendula can tolerate some soil salinity (Perala and Alm, 1990).

Irrigation:

Trees should be watered during periods of drought stress, providing at least an inch of water per week to maintain soil moisture and protect plants from stress, thus controlling the dieback and canker diseases (Pataky, 2005).

Disease control:

The European birch is susceptible to several diseases. Canker diseases are caused by many fungi pathogens (Botryosphaeria, Nectria, Physalospora and Diaporthe spp.). The canker disease infects the sapwood of the birch tree, creating sunken areas on the trunk and large branches of the tree. Canker diseases can be controlled by avoiding wound the tree and maintaining a healthy tree through watering and fertilization. Also, the dieback disease is a fungal disease caused by Melanconium sp., the tree is infected when under stress. It causes a progressive dieback of upper branches (slow death of branches) especially after drought. Dead branches should be pruned out to increase the vigor of the tree and maintain watering and fertilization to have healthy tree. Moreover, a fungal disease Marssonina leaf spot infects the tree at early spring when the buds break; brown spots with yellow rings around the spots appear on the leaves. The tree shed some of its leaves prematurely; this disease can be controlled by applying a fungicide in the spring of the next season, when the buds break (Watson, 1993; Pataky, 2005).

Harvesting:

In seeded and naturally regenerated birch stands intensive pre-commercial and commercial thinning should be carried out two or three times in order to increase the crown and stem growth of European birch trees to ensure profitable production wood by decreasing the competition between the trees, while in planted birch stands, no pre-commercial thinning are usually needed (Hynynen et al., 2009).

Birch sap is collected only at the break of winter and spring when the sap moves intensively. Birch sap collection is done by drilling a hole into the tree trunk and leading the sap into a container via some conduit (a tube or simply a thin twig); the sap will flow along it because of the surface tension. The wound is then plugged to minimise infection (Trummer and Malone, 2009).

Birch sap must be collected in early spring before any green leaves have appeared, as in late spring, it becomes bitter. The collection period is only about a month per year. No published evidence exists to quantify the long-term impacts of sap harvest on birch tree and birch forest health, or birch timber quality (Trummer and Malone, 2009). However, the wounds caused by tapping birches consistently lead to dark staining in the wood (Trummer and Malone, 2009). In one study, infection and wood decay had spread from more than half of old tapping holes (Trummer and Malone, 2009). In comparison to maples, birch trees are considered far less tolerant to the wounds caused by tapping, so more conservative harvesting practices have been recommended by trade bodies such as the Alaska Birch Syrup Makers Association (Trummer and Malone, 2009).

Part III: Utilization

The leaves and bark of Betula pendula are used for their diuretic properties. Ointments for eczema and psoriasis may use birch tar as an astringent ingredient (Beck et al., 2016). Plants for a Future note that, while not especially tasty, the inner bark of the tree can be ground into a meal and used as a source of starch during times of famine. The sap can be harvested in the early spring, boiled, and made into syrup. The sap has also been fermented into beer in the past. Plants for a Future note the leaves can be eaten raw or cooked and steeped with hot water for tea, and also that the young catkins can be eaten raw or cooked. (https://homeguides.sfgate.com/european-white-birch-39026.html)

The outer part of the bark contains betulin. The main components in the essential oil of the buds are α-copaene, germacrene D and δ-cadinene. Moreover, there are other triterpene substances in the bark, which have anti-inflammatory, antiviral and anti-cancer properties (Demirci et al., 2004).

The silver birch commercially is one of the most important sources of hardwood in northern Europe. It is fast-growing and tolerates low temperatures, infertile soils and water deficit. For these reasons, it is widely planted primarily for wood production, but also for, land reclamation and erosion control. The light and porous wood has numerous uses: pulp for paper, plywood, veneer, timber, furniture, and firewood. For its pleasant colours, silver birch is commonly planted in urban areas, roadsides and parks (EU SCIENCE HUB, 2019).

3.2.3 Laurus nobilis (laurel)

Part I: General aspects

Classification:

Latin name: *Laurus nobilis* belongs to Lauraceae family

Commonly known as Bay Tree, sweet bay, Grecian laurel, true laurel

Figure 3.16 General morphology of the laural leaves

Origin and distribution:

Laurus nobilis (see also Figure 3.16) originates from the eastern Mediterranean and Asia. Most bay forests are believed to have disappeared around ten thousand years ago, but some remnants still persist in the mountains of Turkey, Syria, Spain, Portugal, Morocco, the Canary Islands and in Madeira.

Production levels:

Fresh leaf weight of individual tree is decreased from 2.46 kg to 1.71 kg after dried. The global production of dried leaves exceeds two thousand tonnes a year. As Turkey produced two thirds of Laurus trades all over the world, Turkey is considered as the famous producer and exporter of laurus plant. Europe imported about 800 tonnes annually. Low quantities of laurus are imported from Morocco, Israel and Albania (https://uses.plantnet-project.org/en/Laurus_nobilis (PROSEA). Market price of dried leaves averaged $2,000 per tonne.

Plant description:

The Laurel is an evergreen shrub or small tree, variable in size and sometimes reaching 7-18 m tall (Stace, 2010). The Bay Laurel is dioecious shrub, with male and female flowers on separate plants. Each flower is pale yellow-green, and they are borne in pairs beside a leaf. The leaves are glabrous, with an entire margin. On some leaves the margin undulates (Vaughan et al., 2009). The fruit is a small, shiny black berry-like drupe about 1 cm long that contains one seed (Stace, 2010).

Climatic requirements:

Laurus nobilis tree is a plant of Mediterranean climates, though is quite adaptable and has been cultivated successfully from warmer areas in the temperate zone to tropical regions. It grows best in areas where annual daytime temperatures are within the range 17-25 ℃ , but can tolerate 8-30°C (https://en.wikipedia.org/wiki/Laurus_nobilis).

Soil requirements:

Loam, clay and sandy soils are suitable for cultivation, but it prefers well-drained soil. It can be grown in varied pH limits, alkaline, acidic and neutral. It can grow in dry and moist soil. (https://pfaf.org/user/plant.aspx?LatinName=Laurus+nobilis).

Part II: Cultivation Practices

Propagation:

Grow bay from seed, cuttings, or transplanted suckers, where the farmers can begin harvesting leaves at the first year. Seeds are difficult to start. The soil temperature must be kept at 23.9°C (75°F) where seeds may germinate in as few as 28 days, but they sometimes can take up to a year to germinate. While, when cuttings are used, (it can be collected from fresh green shoots) it can take 6 to 9 months to root; cuttings must be kept in moist soil. (https://harvesttotable.com/how-to-grow-sweet-bay/).

Soil preparation:

Rich soil should be used modified with organic fertilizer or well-rotted manure, adding extra grit to improve drainage and plant stability. A ratio of one part sand or extra-fine crushed gravel to six parts enriched soil can be applied.

Planting:

In early fall, the completely mature seeds can be sown in greenhouse. Well-grown seedlings should be transplanted in lonely pots inside greenhouse at least for its first year. After the first year in greenhouse, plants can be transferred to perpetual positions at the first summer season and they must be kept away from cold for the first period of outdoors.

Fertilization:

Since bay is slow growing, it doesn’t require a great deal of fertilizer. Plants in containers need some supplemental fertilizer. Container grown bay should be fertilised in spring and maybe again mid-summer, with a balanced organic fertilizer like fish emulsion and kelp. It also helps to refresh the top couple of inches of soil each spring, being careful not to hurt the shallow roots (https://www.thespruce.com/how-to-grow-your-own-bay-laurel-tree-1402602).

Irrigation:

Bay needs everyday wateringthroughout the primary season to determine a deep, in depth rootage. It needs watering a minimum of once per week or enough to stay the soil systematically dampish however not soggy. Increase watering to double per week throughout extraordinarily hot temperatures or in drought- like conditions. The watering should be reduced as soon as the plant is formed. *Laurus nobilis* is drought tolerant, however appreciates regular deep watering. The soil should be left to dry out between watering, so that the roots don't rot.

Pests and their control:

Bay trees sometimes fall prey to soft-bodied scale, small yellow-brown insects that fix themselves to the stems and suck sap from the plant. On container-grown plants, the whole plant can be sprayed spray insecticidal soap, BioNeem, or a superior oil (available at garden centers) labeled for indoor use, following the directions carefully. Dabbing the scale with a cotton swab soaked in rubbing alcohol is another remedy, but the process is time consuming and usually doesn't entirely eliminate the scale (Chittendon, 1992).

Other cultivation practices:

Growing tips should be pruned to preserve the plant. Container-grown bay plants should be reppoted in larger pots every three years or so. It should also be kept healthy by showering the plant with water a couple of times a year (https://harvesttotable.com/how-to-grow-sweet-bay/).

Harvesting:

Bay leaves can be harvested at any time of the year, but their flavour is strongest in mid- to late summer. Older leaves rather than new ones are recommended to be picked, which generally have more flavor. The essential oils on the leaves dissipate rapidly after harvest, so for better flavour the leaves should be used within a few days (https://harvesttotable.com/how-to-grow-sweet-bay/).

Part III: Post harvest handling

The leaves should be washed before use.

Drying: Bay leaves should be dried before use. Leaves must be dried in a warm, shady spot, not in full sun. Leaves can be set loose on a tray or in a bowl or hang them in a mesh bag. If leaves begin to curl, should bepressed between two boards. Also, bay leaves can be dried in the microwave; leaves can be placed in paper towels for 1 to 3 minutes, checking them every minute to see if they have dried.

Freezing: Leaves can be frozen and used later like fresh leaves. Storing: dried bay leaves can be stored in an airtight container. Dried leaves will lose flavor after about a year. (https://harvesttotable.com/how-to-grow-sweet-bay/)

Part IV: Utilization

Leaves are known as spicy with distinctive flavour which are used in making soup and stews (Chiej, 1984; Bean 1981; Bryan and Castle 1976; Harrison et al, 1975; Facciola, 1990). It is used in arranged Bouquet Garni' as it has essential constituents (Allardice, 1993; Bown, 1995). Flavour of fresh dried leaves or fine divided leaves is characteristics and promising than long stored leaves, more than a year, which caused loss of flavouring ingredient (Bown 1995). Flavour produced from dried fruits is also used (Brouk, 1975; Kunkel, 1974; Facciola, 1990). Herbal tea is prepared from the dried leaves whereas its essential oil is used in the preparation of food as flavouring agent (Facciola, 1990). Percentage of essential oil is ranged between 1 to 3% (Ayse et al., 2016).

Bay tree is considered in folk remedy from ancient times for treating many illnesses as treating bronchitis, influenza, helping in digestion, treating some types of cancers. Both leaves and fruits are used as stimulant internally in veterinary medicines, but it is not preferred to be administered to human when they treat amenorrhoea, hysteria and flatulent colic. Additionally, it was reported by Chevallier (1996) that leaves are promising in treating respiratory tract illness, pain and arthritic aches also used as toner and stimulant by induction of digestive juice, carminative, diuretic, astringent, emmenagogue and narcotic (Grieve, 1984; Chiej, 1984; Lust, 1983; Westwood, 1998; Duke and Ayensu, 1985). On the other hand, leaves essential oil has antibacterial, antifungal and narcotic characters (Ayse et al., 2016). Infusion of fruits is known to have appetite inducer and emmenagogue properties. Moreover, fruit fixed oil used for treating bruises, sprains and it has been used for treating ear pain in the form of drops.

3.2.4 Moringa oleifera (moringa)

Part I: General Aspects

Classification:

Scientific name: *Moringa oleifera*

Common names: moringa, drumstick tree, ben oil tree, benzolive tree, benzoil tree, horse-radish tree, horseradish tree, west Indian ben

Family: *Moringacea*

Figure 3.17 General morphology of the moringa tree and its leaves

Origin and distribution:

Moringa (see also Figure 3.17) is considered originated for southern hills of Himalayas. It was cultivated in other subtropical and tropical regions to be more popular in Asia (Radovich, 2013; Bosch, 2004) and naturally in Caribbean islands, Africa and central America and being important and valuable crop in other countries as Ethiopia, India, Philippines, and Sudan FAO (2014). In ancient civilizations as Egypt, Greece and Roman, it was used to manufacture perfumes. Moringa grows from sea level up to an altitude of 600 m, but it can be found up to 1000 m in the Himalayas, up to 1350 m in East Africa, and as high as 2000 m in Zimbabwe (Radovich, 2013; Bosch, 2004). It requires mild temperature (25-30°C) while lowering temperature may prohibit the growth until reaching optimum again. 1,000 to 2,000 mm of rainfall is recommended for well moringa growth and it tolelates drought as it can grow at 400 mm. It can be developed with full and excellent growth with full sunlight (Radovich, 2013; Bosch, 2004). On the other hand, it can grow with varied limit of soil pH (4.5 to 9) and varied types of soil. It can also tolerate salinity up to 3dS/m through the germination and 8dS/m at start establishing (Nouman et al., 2014; Oliveira et al., 2009).

Production levels:

The largest producer of moringa is India, where an annual production ranged from 1.1 to 1.3 million tonnes of tender fruits from an area of 380 km^2.

Description of the plant:

M. oleifera is a fast-growing, deciduous tree. It can reach a height of 10–12 m and the trunk can reach a diameter of 45 cm. The bark has a whitish-grey colour and is surrounded by thick cork. The tree has an open crown of drooping, fragile branches and the leaves build up feathery foliage of tripinnate leaves. The flowers are fragrant and hermaphroditic, surrounded by five unequal, thinly veined, yellowish-white petals. The flowers are about 1.0–1.5 cm long and 2.0 cm broad. They grow on slender, hairy stalks in spreading or drooping flower clusters, which have a length of 10–25 cm (Parotta, 1993).

Climatic requirements:

It is widely adapted to the tropics and subtropics. It requires high average daily temperatures of 25 to 30°C.

Soil requirements:

Moringa oleifera prefers well-drained soils in the neutral pH range. It can grow well in clay soils.

Part II: cultivation practices

Propagation:

Moringa can be propagated from seed or cuttings. Direct seeding is possible because the germination rate of M. oleifera is high. After 12 days, the germination rate is about 85%.

Soil preparation:

In tropical cultivation, soil erosion is a major problem. So, the soil treatment must be as shallow. For high planting densities plowing is required, while in low planting densities, pits must be dug and refilled with the soil. This produces good root system penetration without causing extensive land erosion. The pits must be 20 to 40 cm wide and 30 to 50 cm deep.

Planting:

Seeds can be grown by direct sown or in a containers, and should be started at rainy season and it should be kept from waterlog, while it use moist of soil. During propagation, it should be adapted to foliage production. Cutting production is suitable for high fruit production (Radovich, 2013; Orwa et al., 2009; Bosch, 2004). Spacing recommended for moringa depends on the target of cultivation; leaves are increased by sowing technique with 5 x 10 cm to 20 x 20 cm spacing (Gadzirayi et al., 2014a; Radovich, 2013; Amaglo et al., 2007). By increasing space of cultivation to 75 x 100 cm, it becomes more suitable for seed production taking into consideration the land use costs (Radovich, 2013; Patricio et al., 2012), whereas 2.5 x 2.5 m is suitable for intercrop production (Radovich, 2013).

Fertilization:

Nitrogen fertilization rates as high as 350 kg N/ha is necessary for positive yield response. Dania et al. (2014) showed that fertilizers, when applied solely or in combination with others resulted in different nutrient compositions on plant parts. NPK fertilizer, poultry manure and organic base fertilizer was provided to study the effect on the nutrient content and found that poultry manure gave the best results than phosphorous, potassium, sodium and manganese. Likewise, the stem girth and vegetative growth of moringa increased on application of poultry manure.

Irrigation:

Quantity of water used according to season:

Rainy season (mid-July to October): 72,000 L/ha/d, at the rate of one hour watering with one bar of pressure;

Dry season (November to mid-July): 108,000 L/ha/d, at the rate of an hour and a half watering with the same pressure.

Disease control:

The moringa tree is not affected by any serious diseases in its native or introduced ranges, but plants may suffer from fruit rots, stem rots, root rot, twig canker, etc.

Other cultivation practices:

To encourage the growth of branches and pods close to the ground, when the tree is 0.6 to 1 m tall (3 to 5 months after planting), it is proposed to prune the apical shoot (10 cm from the top). The second pruning strategy proposed is to cut back each branch by 30 cm, when it reaches 60 cm in length. This will produce a multi-branch shrub. Older trees that are unproductive or too high for easy harvesting can be pruned at ground level. Farmers should do at least 2 pruning per year, and harvesting can be the occasion to prune.

Harvesting:

Moringa has an outstanding growth rate and can be harvested for foliage in less than 2.5 months. Optimal cutting intervals range from 15 to 75 days, depending on local conditions (Nouman et al., 2014; Amaglo et al., 2007). Up to 9 cuttings / year can be achieved (Radovich, 2013; Bosch, 2004). Highest growth and forage yield are obtained under warm, dry conditions, with some supplementary fertilizer and irrigation (Radovich, 2013). Plant management is important for leaf production. Pollarding and coppicing promote leafy regrowth and enhance leaf yield (Orwa et al., 2009).

Moringa trees grown for pod production can be harvested 7 months after planting. Pod yields are about 19 kg pods/tree/υ, equivalent to 30 pods/ha/υ (Radovich, 2013). In Tanzania, seed yield was reported to be about 3.3 kg/tree/y (Bosch, 2004), which corresponds to 1 to 1.5 t/ha of oil (Sengupta et al., 1970).

Part III: Post-harvest handling

Moringa can be preserved for a long time without loss of nutrients. Drying or freezing can be carried out to store the leaves. A report by Yang et al., (2006) shows that a low temperature oven used to dehydrate the leaves retained more nutrients except vitamin C than freeze-dried leaves. Hence, drying can be done using economical household appliance like stove to retain a continuous supply of nutrients in the leaves. Preservation by dehydration improves the shelf life of Moringa without change in nutritional value.

The harvested branches are washed in treated water once the trees are cut, to remove sand and dust from the leaves. During the harvesting and leaf cleaning time, workers must frequently wash their hands with soap and remove shoes or boot before entering the drying room. After the rinsing, the leaves are manually stripped from the branches and put into a basket for transport to the drying room. The fresh leaves are spread onto the screened trays in thin layers to permit easy air circulation.

After drying, the leaves are crushed using a diesel-powered hammer mill. The leaf powder is placed in plastic bags of 200 g, 1 kg or 4 kg, which are sealed shut using a plastic welder.

Part IV: Utilization

It is used in cooking (leaves, pods, roots and flowers). Roots are used as a substitution of horseradish with some toxicity. Leaf contains vitamin A, vit. B, vit. C and protein in rich margin and they are recommended for preganan and nursing times (FAO, 2014). In addition, it is used for many applications as fragrance, paints and lubricants (Bosch, 2004; Foidl et al., 2001). In last decade, oil is used for biodiesel production (Rashid et al., 2008).

The medicinal uses/benefits of Moringa cannot be exhausted. This is because almost all parts of the tree have been utilized within traditional medical settings. The flowers, leaves and roots are used for the treatment of ascites, rheumatism and venomous bites and as cardiac and circulatory stimulants in folk remedies. The oil is applied externally for skin diseases. The roots of the young tree and also root bark are rubefacient and vesicant Leaf juice is used in hiccough (emetic in high doses); cooked leaves are given in influenza. The root-bark is used as antiviral, anti-inflammatory, analgesic. Stem-bark and flowers are hypoglycaemic.

3.2.5 Quercus ithaburensis (Tabor oak)

Part I: General aspects

Classification:

Scientific name: *Quercus ithaburensis* Decne

Common name: Mount Tabor oak, Vallonea oak, Palestine oak or Tabor oak

Family: Fagaceae

Figure 3.18 General morphology of the Tabor oak tree and its leaves

Origin and Distribution:

The tabor oak (see also Figure 3.18) is a deciduous oak species native to the East Mediterranean basin. Taxonomists describe two different subspecies that are geographically separated: Q. ithaburensis subsp. Macrolepis (Kotschy) Hedge & Yalt., known as vallonea oak, which is present in the north east of the Mediterranean basin (Turkey, Greece, and southeastern Italy), and Q. ithaburensis subsp. Ithaburensis, known as Palestine oak or Tabor oak, the subspecies that is present in the Levantine countries within the Eastern Mediterranean basin (Palestine, Israel, Jordan, Syria, and Lebanon) and which is the concern of this article (Tutin et al., 1993; Strid and Tan 1997).

Description:

Tabor oak trees are rounded and hemispherical, reaching 15 m in height. The trunk is corky with many protuberances. Branches are grey and form a spreading habit. The young shoots are hairy, soft, and grey. Buds are ovoid, with suppressed hairy scales. The leaves are broad-ovate, leathery with teeth, semipersistent, and late to fall. The acorns are solitary or in a cluster of 2 or 3. The cupule is large in diameter (3.5 cm), and the scales are thick, lanceolate, and recurved. The nut (gland) is longer than the cupule (5 cm). The size of the nut, the percentage of the covered part, the cupule diameter, and the size of the scales are key traits that differentiate the subspecies.

Climatic requirements:

It prefers low to middle altitudes, on the subhumid bioclimate and on shallow to moderate deep calcareous soils. All these characteristics, combined with human activities, influence vegetation types in each region. Due to climate and various human interventions, the Mediterranean elements dominate and only in the forests found in the more northern regions the percentage of the submeditteranean elements increase considerably. Additionally, Q. ithaburensis ssp. Macrolepis forests are characterized by the dominance of therophytes, (Pantera, et al., 2009). It is well adapted to Mediterranean conditions and warm dry periods, develops a deep root system, regenerates easily after fire and is used in many restoration projects (Tsitsoni et al., 2015).

Soil requirements:

The species develops in a variety of rock and soil types, slope inclinations, aspects and different types of Mediterranean bioclimates. It prefers low to middle altitudes, on the sub humid bio-climate and on shallow to moderate deep calcareous soils. All these characteristics, combined with human activities, influence vegetation types in each region. Due to climate and various human interventions, the Mediterranean elements dominate and only in the forests found in the more northern regions the percentage of the sub-meditteranean elements increase considerably. Additionally, Q. ithaburensis ssp. Macrolepis forests are characterized by the dominance of therophytes (Pantera et al., 2009).

Part II: Cultivation practices

Propagation:

Plants of oak species used for reforestation are traditionally raised from seed. The vegetative propagation of oak was considered difficult and has not been successful on a commercial scale. In many regions, good acorn harvests are not frequent and acorns are difficult to store. The vegetative propagation of oak may provide an adequate plant supply when there is a natural shortage of seeds and could reduce the demand for seed-grown planting stock, especially during years following poor seed harvests (Chalupa, 1993).

Soil preparation:

According to Tsitsoni et al. (2015), container seedlings were enhanced by the favourable growth conditions; their better performance could be attributed to the moist and friable artificial medium of sufficient volume that they were grown in relation to the nursery field soil. The artificial medium peat: perlite (1:1) has better structure and aeration than the nursery field soil so it was easier for the roots of container seedlings to absorb the necessary nutrients and water for their growth. Pantera et al., (2009) found that acorn germination of *Quercus ithaburensis* subsp. Macrolepis is not affected by soil compaction, but under high soil compaction the seedlings ’growth was negatively affected.

Planting:

Accordning to Montagnoli et al. (2018), acorn water loss due to desiccation follows an almost linear pattern for the subspecies macrolepis, while in the case of subspecies ithaburensis, it follows a negative exponential model. Accordingly, the germination behavior was found highly dependent on water loss for both subspecies. The low acorn water content (15%) achieved after 15 days of drying was crucial for the ssp. Macrolepis, while it had no effect on seed viability in ssp ithaburensis, that needed a subtle further water loss to reduce its germinability (i.e. <14.5% mc). The results suggest that intraspecific differences in seed responses to drying may be due to different adaptation to survive drought after dispersal and contribute to explain the ability of ssp. Ithaburensis to grow in the hottest and driest Mediterranean bioclimates.

Fertilization:

According to Enroque et al. (2011), autumn fertilization, especially with N, does not reduce the quality of the plants, but improves the overall growth, the cold resistance, and the nutritional content of the plants. However, autumn fertilization had only a small effect on field performance, which was affected only by K fertilization, probably because of the adequate N and P nutrient status of all the plants and the mild weather conditions of the field plot. At the site of the aforementioned study, site, which had a mild winter climate, late autumn out-planting, was more successful than was midwinter out-planting.

Irrigation:

In the study of Siam et al. (2009), it was found that soil water depletion led to a reduction of both predawn and afternoon C and Cp in all studied Quercus species until early August. However, under progressive drought, water-stressed seedlings of Q. ithaburensis maintained significantly higher C and Cp than the other species. The lowest C and Cp were detected in late July for Q. ithaburensis and early August for the other species when drought became severe. Minimum C values were 5.3, 3.2 and 5.8 at predawn and 5.9, 3.6 and 5.8 at afternoon in non-watered plants of Q. pubescens, Q. ithaburensis and Q. frainetto, respectively. Unwatered seedlings of Q. pubescens and Q. frainetto exhibited significantly lower C and Cp compared to the controls. Consequently, complete shedding of leaves was observed in water stressed Q. frainetto after 4th August when C declined to as low as 39.7% and 58.6% of control levels at predawn and afternoon, respectively.

Disease control:

To prevent damage of fungal diseases trees should be watered and fertilized properly. This includes furnishing iron to Texas red oaks that develop chlorosis. Trees deficient in iron are under stress and are more susceptible to many foliage pathogens. Rake and destroy fallen leaves and use copper, maneb, zineb or benomyl-containing fungicides when needed. Good care is the most effective means of preventing the onset and development of disease. Deep watering during July, August and September is important in preventing moisture stress. Wood from infected trees should not be stored near healthy trees. If the fungus occurs on a scaffold limb, it must be removed to stop pathogen development. Cuts should be made 24 to 36 inches below the visible damage to minimize the chance that the fungus has developed beyond the point of the cut. The effectiveness of pruning is determined by the early detection of infection. In addition, all pruning equipment should be sterilized before and after work on diseased trees (Johnson and Appel, 2006).

Harvesting:

The production of acorn and income will be revealed, and the materials and usage areas of acorn will be emphasized. Tannin, which is found especially in *Quercus ithaburensis* Decne subsp. macrolepis (Kotschy) HedgeYalt and shows its ability to be hydrolyzed, is often used in sepsis (tanning). Tannin is different in each organ of the plant. Gallic tannins are found in the nails on the goblet of oak, while tannins in the pellet are lower. The rate of tannins in the goblet of oak is quite high. This ratio is shaped by the characteristics of the plant and the characteristics of the growing environment (Çizgen et al., 2017).

Harvesting begins in late September and lasts through to the first weeks of November when the acorns and acorn caps fall, ripe and dry to the ground. Trees that have been identified as yielding optimum acorns should be carefully monitored to determine optimum harvest time. Heavy spring rains usually result in higher acorn set (Pearse and Kroenig, 2014).

Part III: Post-harvest handling

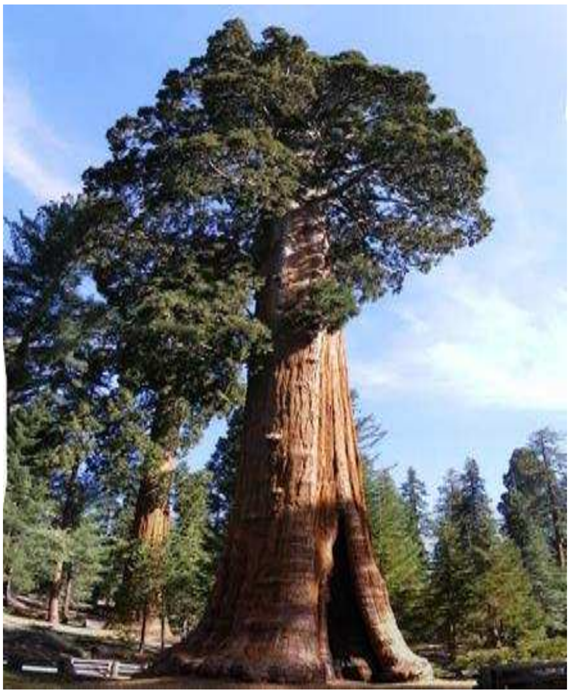
Acorns are ready to store when the moisture level in the nuts reaches 10%. Acorns must be stored in a sealed, dry area, preferably in wooden boxes. When plastic crates are the only storage available, an unfinished piece of timber is buried in the center of each crate to absorb moisture. Crates can be filled with acorns to a depth of 20-25 cm (8-10 in) and should be stacked in a manner that allows air to flow through the crates. Acorns can also be stored in clean water for months, preferably in stainless steel containers with enough cold water to keep the nuts covered. All acorn nuts must be leached and dehydrated, including those stored in water, before they can go to the flourmill (Maroulis, 2014).

Part IV: Utilization

Up to the last century, the main uses of the species were for wood and acorn production (Giannakopoulou, 2002). Furthermore, tannins extracted from Q. ithaburensis ssp. macrolepis acorn cups supported a great tannery and dye industry (Ioannidis, 2002). The oak bark raw material is described as the cut and dried bark of young branches and lateral shoots which contain a minimal amount of 3% of tannins which is composed of either: galloyl esters and their derivatives (gallotannins, ellagitannins and complex tannins) or oligomeric and polymeric proanthocyanidins and can possess different interflavanyl coupling and substitution patterns (Niemetz and Gross, 2005; Bobinac et al., 2012). According to Bashar et al. (2006), the in vitro study indicated no significant changes of LDH levels in the culture medium were seen after 24 h of exposure to extracts from J. regia and Q. ithaburensis. As seen with HepG2, LDH levels were not significantly increased after treatment with extracts from J. regia and Q. ithaburensis.)

3.2.6 Sequoiadendron giganteum (sequoia)

Part I: General aspects



Classification:

Scientific name: *Sequoiadendron giganteum*

Common names: giant sequoia; giant redwood, Sierra redwood, Sierran, redwood, Wellingtonia or simply big tree

Family: Cupressaceae

Figure 3.19 General morphology of the sequoia tree and its leaves and pines

Origin and distribution:

Giant sequoia (see also Figure 3.19) naturally found in the Sierra Nevada, California in isolated concentrations traditionally known as groves (Willard, 1994). These groves varied in area and number of plants grown in it. The total area of these groves is about 14,410 ha (Weatherspoon, 1990). Nowadays, giant sequoia tree is planted in Europe countries latitudes of about 39° and 61°.Giant Sequoias planted between Norway and the Black Sea, and between the Mediterranean and the Baltic Sea, most of the European plantations are located further to the north and have colder, wetter weather (Knigge, 1994).

Production levels:

In a survey of California plantations, the best plantations of giant sequoia averaged 0.5-0.7 m per year in height growth, and 1.3-2.0 cm in diameter growth per year. In another study the mean annual increment for sequoia trees at age 86 was approximately 9 m^3/ha (Weatherspoon, 1990). In its native California habitat, mature trees will often grow to 200-275 in (508-698.5 cm) tall200-275', produce trunk diameters ranging from 15-20 in (38.1-50.8 cm)weigh 200 or more tonnes. Trees may live 2,000-3,000 years.

Description of the plant:

Giant sequoia is evergreen tree which considered being the most massive individual trees in the world. They grow to an average height of 50–85 m with trunk diameters ranging from 6–8 m. It is monoecious since male and female cone buds carried on the same plant, they form at late summer. Giant sequoias form the cones which at maturity may remain attached to the stems without opening to release seeds. A mature plant produces an average of 1,500 new cones each year (Willard, 1994).

Climatic requirements:

Giant sequoia is found in a humid climate characterized by dry summers. Mean annual precipitation in the groves varies from about 900 to 1400 mm (Weatherspoon, 1990). Concerning the temperature, the mean daily maximum temperatures in July at typical groves are 24 - 29°C while the mean minimum temperatures for January vary from 1 to -6°C.

Soil requirements:

Best grown in moist, deep, loose, well-drained, sandy loams in full sun. Tolerates some light shade. Avoid heavy clays. (http://www.missouribotanicalgarden.org/PlantFinder/PlantFinderDetails.aspx?taxonid=287324)

Giant sequoia grows best in deep, well-drained sandy loams. Soil pH ranges mostly from 5.5 to 7.5, with an average of about 6.5 (Weatherspoon, 1990). Suitable soil moisture during the dry growing season is critical for successful establishment of giant sequoia regeneration. Sandy soils of the groves normally provide the additional requirement of adequate aeration and the optimum pH range (Stark, 1968).

Part II: Cultivation practices

Propagation:

The development of natural reproduction in giant sequoia is an unusually weak process. Numerous seeds shed each year, the conditions needed for the seeds to germinate and the seedlings establish is not found since most of giant sequoia seeds die from dryness and solar radiation soon after reaching the forest ground. Sexual propagation can be used by sowing seeds, while cuttings at dormancy period from juvenile donors is the method of vegetative propagation that root quickly and in high percentages up to 94 % (Fins, 1980; Fins and Libby 1982).

Soil preparation:

Mixing peat moss into soil may seem beneficial, but it can hinder your tree in the long run. Understand giant sequoia's growing needs and the challenges soil amendments such as peat moss can cause. You'll see the bigger picture, save on peat moss and have a healthier giant sequoia.

Planting:

After few weeks from seeds germination or the establishment of the seedlings should be propagated by cuttings, when the seedlings begin to produce new branches. Since giant sequoia trees suffers from shade and need sun light, it should be planted with distances at least 4 x 4 m (Knigge, 1994), and it is preferred that the seedlings can be transplanted in a large area with radius at least 10 meters. Best planted into its permanent position when no more than 30 - 50 cm tall (Huxley, 1992). Trees are notably susceptible to honey fungus (Rushforth, 1987; Huxley, 1992). The foliage is hard and harsh to the touch and readily emits a scent of aniseed (Mitchell, 1975). Cones take 2 years to mature (Sargent, 1965). In its native habitat the cones are retained on the tree with viable seed for up to 30 years (Mitchell, 1975). The cones open after the heat of a forest fire (Huxley, 1992). Special Features: Attracts birds, North American native, in conspicuous flowers or blooms.

Fertilization:

Weak and moderate acidic soil seems to be a favorable, no fertilization doses are recommended. The plant makes a symbiotic relation with mycorrhiza fungi which inoculate the roots and serve as extensions of plant roots, taking up nutrients and water and transferring them to the roots (Molina, 1992).

Irrigation:

The roots of the sequoia tree expand quickly into the lower horizons of the soil profiles, so they are capable of reaching the upper levels of groundwater (Knigge, 1994). The annual precipitation at the native groves of giant sequoia ranges between 900-1400 mm all over the year (Weatherspoon, 1990).

Disease control:

Trees planted in the native areas are more tolerant to pathogens and pests that can attack it, while the trees planted in another area are susceptible. At stand development stage of trees, the trees are severely damaged by a canker fungus (Botryosphaeria sp.) or by Armillariamellea. Moreover, at maturity stage, the death of the trees is resulted from uprooting or stem break in addition to the fire, lightning and environmental damages (Parmeter, 1986).

Harvesting:

At areas closer to its native range giant sequoia plant has been planted in industrial forestry (Kitzmiller and Lunak, 2012). Because it is highly sensitive to competition in both diameter and height, growth can be influenced greatly by planting and thinning treatments, to avoid competition-related reductions in individual tree growth, thinning would be necessary at early stages (year 4 on productive sites).Then thinning treatment by year 10 would seem appropriate for maintaining rapid stem growth and to produce either a variable density or low density stand (York et al., 2013).

Part III: utilization

The giant sequoia timber is characterized by strength, beautiful color and high durability. The wood processed to produce many products such as doors, sidings and ceilings, fences, poles, boxes and crates. The smoothness of its surface and its low shrinkage and swelling recommend its wood for pipes and flumes as well as for garden furniture and boat building,(Knigge, 1994).The essential oil of the needles and wood of giant sequoia are rich in monoterpenes, with α-pinene as the major components and it considered to be anti-inflammatory and anti-microbial (Jerkovic et al., 2003).

3.2.7 Tilia tomentosa (silver linden)

Part I: General Aspects

Classification:

Scientific name: *Tilia tomentosa*

Common name: silver linden, silver lime or European white linden

Family: Malvaceae

Figure 3.20 General morphology of the silver linden tree and its flowers

Origin and distribution:

Tilia tomentosa (see also Figure 3.20) is native to southeastern Europe and southwestern Asia, from Romania and the Balkans east to western Turkey (Rushforth, 1999).

Plant description:

Tilia tomentosa is a deciduous tree growing to 20–35 m tall, with a trunk up to 2 m in diameter. The leaves are alternately arranged, rounded to triangular-ovate, 4–13 cm long and broad with a 2.5–4 cm petiole, green and generally hairless above, densely white tomentosa with white hairs below, and with a coarsely toothed margin (Mitchell, 1974). The flowers are pale yellow, hermaphrodite, produced in cymes of 3 to 10 in mid to late summer with a light inexperienced subtending leafy bract; they have a strong scent and are pollinated with the aid of honeybees. The fruit is a dry nut-like drupe 8–10 mm long, downy, and slightly ribbed (Mitchell, 1974).

Climate requirements:

Trees of Tilia can grow under partial sun conditions and in fully sunny conditions (Rushforth, 1999).

Soil requirements:

As most trees, it can be grown in loam, clay and sandy soils but it prefers well-drained soil with varied range of pH including acidic, neutral and alkaline. Dry or moist soil can facilitate tree growing (https://pfaf.org/user/Plant.aspx?LatinName=Tilia+tomentosa).

Part II. Cultivation Practices

Propagation:

By Several Methods: like; Seeds (with difficulty, It can take two years to germinate), Layering, Grafting or Chip-Budding onto a suitable rootstock.

Planting:

The dormanced seeds (silver lime) need time to reach level of germination. Draining substrate should be prepared firstly before mixing seeds. The mixture may be of compost and sand or vermiculite and perlite (50%) and should be sure about the material volume is suitable. Seed mixture should be placed in plastic bags especially those have zip-lock and then kept until starting. Warming is required for seeds (20^{o}C) for sixteen weeks while making sure not to dry at any period. After warm, it needs cold time (4^{o}C) to breakdown the last part dormancy time. If seeds are ready for germination it can be carefully removed from bags. It can be firstly planted in pots or trays with high grade compost with covering by thin layer (1 cm in depth). In case of large amounts, seeds will be prepared in outdoors using seedbed and left until germination. Outdoor germination may also require heat chock of warm and cold but by naturally occurring weather. Seeds can be used until five years of their old. Seedlings should be kept in watered and weed free medium at 25 ^{o}C. Seedlings should be kept one or two years until reach optimum growth to allow them for cultivation in permanent areas. Layering can be applied in spring at one to three years old plants (Sheat, 1948).

Suckers, when formed, can be removed with as much root as possible during the dormant season and replanted immediately (Huxley, 1992).

Chip pudding is the most appropriate method.

This tree is large and needs a lot of space to grow. It should be planted in a place where there is plenty of space in the ground for root expansion. It is suitable for large lawns with trees along roads. Silver Linden should be grown in full sun, on moist, well-drained soil, acid or slightly alkaline. This tree is moderately tolerant of pollution, soil compaction, heat, and drought making it an ideal street.

Fertilization:

Young plants need extra phosphorus to encourage good root development. Fertilizer with phosphorus, are sugg (the second number on the bag.) So fertilizer with phosphorus is ecommended to be applied foin the soil at time of planting or at least during the first growing season.

Established plants can benefit from fertilization. Trees need to be fertilized every few years. Shrubs and other plants in the landscape can be fertilized yearly. A soil test can determine existing nutrient levels in the soil. If one or more nutrients are low, a specific instead of an all-purpose fertilizer may be required. Fertilizers that are high in nitrogen will promote green leafy growth. Excess nitrogen in the soil can cause excessive vegetative growth on plants at the expense of flower bud development. It is best to avoid fertilizing late in the growing season. Applications made at that time can force lush, vegetative growth that will not have a chance to harden off before the onset of cold weather.

Irrigation:

Irrigation should be applied regularly after planting.

Disease control:

Anthracnose, leaf blight, canker, leaf spots, powdery mildew, and verticillium wilt can be occasional problems on lindens.

Harvest:

Plausible flowers to be harvested are those that have shiny green leaves attached to flower stem. Ten percentage of observed flowers are harvested while others are remained for pollination to persist life cycle of tree. Harvesting must be carried before turning into brown. The brownish flowers have narcotic property. Buckle flowers are harvested by hands.

Part III: Post-harvest instructions

Flowers can be dried at homes on brown paper in darkened and well ventilated area. After drying, linden can be used forn tea.

Part IV: Utilization

Linden remedy properties can be concluded as nervine to relief nervous system, anxiolytic to decrease anxiety, antispasmodic in relaxing cramped muscles, anti-hypertension for decreasing blood pressure, vasodilator for dilatation of blood vessels, demulcent as moisturizer, diaphoretic to induce perspiration and as anti-inflammatory.

The dried inflorescences of linden or lime tree are widely used traditionally as herbal tea. The Commission has approved linden flower for colds and cold-related coughs (Blumenthal, 2000). The British Herbal Compendium indicates its use for upper respiratory catarrh, common colds, irritable coughs, hypertension and restlessness (British Herbal Compendium, 1992). The volatile constituents of Tilia species have been the subject of several studies (Bernasconi and Gebistorf, 1968; Idal and Richard, 1986). Additionally, the inhibitory effect of linden flower (mainly T tomentosa) and its alcohol extract on the growth of food borne pathogens has been examined (Yildirim et al., 2000).

3.3 Edible Shrubs

3.3.1 Arbutus unedo (strawberry tree)

Part I: General Aspects

Classification:

Scientific name: *Arbutus unedo*

Common name: strawberry tree, Irish strawberry tree, cain, cane apple , Killarney strawberry tree

Family: Ericaceae

Figure 3.21 Genera morphology of the strawberry tree and its fruits

Origin and distribution:

Arbutus unedo (see also Figure 2.21) is native in many regions: in Northern Africa (Algeria, Morocco, Tunisia), in western Asia (Lebanon, Syria, Turkey), in south eastern Europe (Albania, Bulgaria, Croatia, Greece, Crete, Italy and Sicily), in southwestern Europe Portugal, Spain and France, in Northern Europe (Ireland) (USDA, 2019 b).It is also cultivated in USA and Australia (Orwa et al., 2009).

Production levels:

The fruit production usually is not very high and varies depending on the weather, so, this may be the main reason that this plant is not cultivated extensively. Molina et al. (2011) studied the fruit production of strawberry tree at two different sites in Spain and results showed that the average yield is around 46 kg per hectare, and 180 grams per m^3 of crown. Moreover, the yield of strawberry tree at wild population was about 2.6 kg/tree and about 539 kg/ha. The strawberry tree is native at some countries in North Africa (Algeria, Morocco, Tunisia), but it is not distributed at southern Africa (Orwa et al., 2009).

Description of the plant:

Arbutus unedo is an evergreen broadleaved shrub or small tree, that can reach up to 12 m height but usually is much lower. The Leaves are simple, alternate, serrated and 5 - 10 cm long. The flowers are hermaphrodite, white bellshaped flowers that produced on a panicle inflorescence (10-30 flower/panicle), pollinated by bees. The fruit is berry, covered in conical swellings, ripening from yellow to red and deep crimson, edible and 2 cm in diameter (Orwa et al., 2009).

Climatic requirements:

The strawberry tree needs average temperature of 13 – 19°C and can tolerate temperatures down to -16°C (Orwa et al., 2009). In addition, Gilman and Watson (1993) mentioned that strawberry tree can grow at USDA hardiness zones from 8 through 11. Also, it grows at altitude 0 – 4,000 m. Strawberry tree need rainfall 600 – 800 mm (Orwa et al., 2009). It is an easy plant to cultivate and is adaptable to many climates. Once established, it is fairly drought resistant, frost resistant, shade tolerant and salt tolerant.

Soil requirements:

The strawberry tree can grow at many soil structures and conditions; clay, sand, loam, acidic, alkaline, well-drained dry or moist soil. In addition, the trees are salt tolerant (Orwa et al., 2009).

Part II: Cultivation practices

Propagation:

Seeds can be used for propagation of the strawberry tree plant, in addition to layering and cutting. Seeds need to be treated with cold stratification treatment for one month before cultivation (Pipinis et al., 2017). The seed germination rate is low about 20%. Layering can take up to two years, but has a good success rate, while cutting is done with a 15–20 cm in mature wood, preferably with a heel in November to December.

Soil preparation:

Soil tillage improves the soil conditions, it is important to maintain relatively smooth, level ground for orchard work and harvesting. Organic matter can be added to the soil in order to improve the soil properties also it enhances the growth of the plants in poor soils.

Planting:

After the seeds germinate, it is better to transplant it in separate pots when they reach the optimum growth for handling, kept in good ventilation green house for at least the first winter for them. They should be transferred to outdoors in late spring, after ending the last frosts season. The standard planting distances are 4 x 4 m (Molina et al., 2011).

Fertilization:

Strawberry tree plant forms a mycorrhizal relationship. Inoculation with Pisolithus tinctorius improves their plants root mass, size, tolerance to drought and nutritional status (Navarroet et al., 2009).

Irrigation:

Strawberry tree need rainfall 600 – 800 mm (Orwa et al., 2009), additional irrigation water can be added by drip or sprinkler irrigation. Young plants will grow faster and larger with regular moisture during the winter to spring growing season.

Disease control:

One of themany diseases that threat the strawberry tree is Anthracnose that attacks stems, leaves, flowers and fruit and is commonly named tree blight. If the infection is severe it destroys leaves, twigs and creates cankers on the trunk and branches. Young trees are the most vulnerable to anthracnose. The fungi are spread via piles of dead tree branches, twigs and leaves on the ground. Also, it can be controlled by using suitable fungicide. Besides Anthracnose, the strawberry tree is infected by Phytophthora that includes root and crown rot diseases, its symptoms are leaf discoloration, water soaked and wilted foliage plus retarded growth. Young trees are more susceptible andit may take a few seasons for phytophthora to kill older trees. Phytophthora thrives in poorly drained soil and spreads when infested soil is transplanted to other locations.Fungicides can help prevent infections (Miller, 2020).

Strawberry trees can be also infected by a fungal disease called rust that develop spores of red, yellow and orange filled with powder on leaves. The disease increased at high humidity conditions. Rust disease can be manual controlled by cutting off infected foliage. Also, chemical control can be used by spraying appropriate fungicide (Miller, 2020).

Other cultivation practices:

Pruning can be done to enhance shape; by training the tree as a single-trunked tree or to open up tree crown. In addition, new shoots can be pruned back to 2-3 leaves during growth (Orwa et al., 2009).

Harvesting:

Strawberry fruits are harvested manually. Fruits mature in about 12 months. It is edible; the fruit is sweet when reddish (Molina et al., 2011; Ogaya and Peñuelas, 2004).

Part III: Postharvest handling

Fruit showed a climacteric pattern of ethylene production between 3 and 7 days of storage. Fruits are stored at 0°C temperature which sustain most general and nutritional fruit quality parameters.

Part IV: Utilization

Strawberry tree fruits are rarely eaten as fresh fruits, but have some importance in local agricultural communities where they are used for the production of alcoholic beverages, jams, jellies and marmalades (Molina et al., 2011). Fruits are also used in folk medicine as antiseptics, diuretics and laxatives, while the leaves have long been employed as an astringent, diuretic, urinary anti-septic agent and, more recently, in the therapy of hypertension and diabetes. Leaves are used in the treatment of diarrhoea and dysentery as well as making gargle from it for treating sore and irritated throats. The flowers are weakly diaphoretic. Strawberry tree fruit contain wide range of antioxidants such as phenolic compounds (e.g. anthocyanins, gallic acid derivatives and tannins), Ascorbic acid, vitamin E and carotenoids (Fortalezas et al., 2010).

3.3.2 Corylus avellane (hazelnut)

Part I: General aspects

Classification:

Scientific name: *Corylus avellane*

Common name: common hazel, hazelnut , European hazel

Family: Betulaceae

Figure 3.22 General morphology of the hazelnut tree, flowers and the nuts

Origin and distribution:

Corylus avellana L. (see also Figure 3.22) is a species of hazel that is native in Europe and western Asia, from the British Isles south to Iberia, Greece, Turkey and Cyprus, north to central Scandinavia, and east to the central Ural Mountains, the Caucasus, and north western Iran (Enescu et al., 2016)

Production levels:

The world production of hazelnut with shells is 1,006,178 tonnes (FAOSTAT, 2017). Also, the yield average of hazelnut with shells is approximately 1.5 t/ha. The top hazelnut production countries are Turkey, Italy, Azerbaijan, and USA. Turkey produces about 675000 tonnes (FAOSTAT, 2017).

Description of the plant:

European hazel is a shrub that can reach up to 4-8 m tall, sometimes it may exceed 10 m tall, and the stem is usually branched. The shrub bark is grey with white and large spots. The shrub is deciduous, and the leaves are rounded, 6-12 cm long, with a double serrate margin and hairy on both sides. The flowers appear in early spring, before the leaves. European hazel plant is monoecious with single sex wind pollinated catkins. Male catkins are usually grouped together (2-4 flowers) and are yellowish-brown and up to 10 cm long, while female catkins are very small. The male inflorescences (aments) form on the small branches without leaves during the summer and can be seen during the winter on the bare plant. The female flowers develop in spring together with the leaves. They are small and difficult to see, hidden among the buds of the one-year-old branches, from which are visible only the charming red styles. During flowering, the inflorescence becomes thin and double in length. The fruit is a nut, grouped in clusters of one to four together. Each nut is held in a short leafy involucre (husk) which encloses about half of the nut. The nut is roughly spherical, up to 2 cm long, yellow-brown with a pale scar at the base (Enescu et al., 2016)

Climatic requirements:

Hazelnut prefers moderate climates with enough high temperatures during the growing season, but it can resist cold temperatures or even frosts. In Turkey an average temperature of 13-16°C and rainfall of over 700 mm is considered to provide optimal conditions for hazelnut cultivation (Enescu et al., 2016). The cold temperature (-10°C and below) during the flowering time can destroy flowers and reduce fruit set (Alfrey, 2017).

Soil requirements:

The European hazelnut thrives at fertile and nutrient-rich, slightly acid or neutral soil. Besides it can grow well on dry calcareous soils (Enescu et al., 2016; Savill, 2019).

Part II: Cultivation practices

Propagation:

Hazelnut can be propagated both by sexual and asexual propagation methods. It is commonly propagated by shoot and root suckers and cuttings (Enescu et al., 2016)

Soil preparation:

Break hardpan soils, which may be located up to 45 cm under the soil to ensure that excess water can drain through the subsoil (Leuty et al., 2012). Soil tillage improves the soil conditions and is important to maintain relatively smooth, level ground for orchard work and harvesting. Organic matter can be added to the soil in order to improve the soil properties, enhancing the growth of the plants in poor soils.

Planting:

The plants can be planted at 6-7 m between rows and 4 m between trees (Leuty et al., 2012). Dormancy in seeds of hazel (Corylus avellana L.) and beech (Fagus sylvatica L.) has been studied with special reference to changes in growth-promoting and inhibiting substances after-ripening. About 12 weeks at low temperature and under moist conditions is necessary for complete after-ripening. Gibberellic acid, kinetin, and thiourea stimulate germination in dormant seeds but have no effect on nuts with the pericarp intact. Gibberellin 'D 'is ten times more active than gibberellic acid (Frankland and Wareing, 1966).

Fertilization:

At poor orchards, 30 L of compost can be applied to the surface of the soils and is very effective if repeated every spring for 4-5 years (Alfrey, 2017).

Irrigation:

Young hazelnut trees are very susceptible to drought, while established hazelnut trees will tolerate relatively dry soils, as the roots can penetrate down into moist soil layers.

In warm regions with hot summers and long periods without rain, applying 30 L of irrigation water per tree every 3-4 weeks is necessary (Alfrey, 2017).

Disease control:

Pseudomonas avellana and P. syringaepv. coryli are responsible for the bacterial canker and decline of hazelnut. The symptom of the disease is sudden wilt of the twigs and branches, especially at the end of spring and during the summer (Enescu et al., 2016). Eastern Filbert Blight is caused by the fungus Anisogram maanomola and is fatal to trees. Bacterial Blight caused by Xanthomonas campestris pv. corylina causes leaf spotting, dieback of branches and in worst cases death. Trees under stress are most susceptible.

Other cultivation practices:

Hazel plants often sucker (send up many shoots from the base of the plant), uckers should be removed to keep the stems clear and the crown less congested.

Harvesting:

The nuts are fully ripe when the husks begin to yellow and can be picked by hand. Pick them from the tree, or if they're perfectly ripe you may be able to shake them off onto a tarpaulin or sheet. Store the nuts in a dry, airy place within crates, nets, cloth bags or slatted boxes. Nuts will naturally drop over a 4-6 week period. It's important not to pick them before they are ripe as they will shrivel (Alfrey, 2017).

Part III: Postharvest handling

After harvesting, the yield is transported to the primary processing facility where they are de-husked, cleaned, washed, sanitized, and dried. The husk must be removed from the husk. This can be done by hand on the inspection belts or with a brush or scrubber placed in front of the cleaner on the processing line, then the cleaner removes trash and deposits the nuts on a conveyer, where they are inspected, and any remaining debris is removed. Finally, the nuts are dried to 5-8% moisture content to prevent the nuts from becoming rancid or mouldy. The harvested nuts should be dried within 24 hours after harvest. Optimal drying temperatures are 32.2 to 38.0°C. At this temperature, it takes 2-3 days to reduce the moisture level to the required 5-8% so they can be stored and kept dry (Leuty et al., 2012).

The European hazelnuts are sorted according to the nuts diameter to jumbo (with minimum diameter 22 mm), large (22-19 mm), medium (19.4-19 mm) and small less than 19 mm. Since Hazelnut has very low water content, they can be frozen in the shell or as kernels. When stored at -3.9 to -2.8°C, with 60-65% relative humidity, hazelnuts may be kept in bulk for up to 4 years (Leuty et al., 2012).

Part IV: Utilization

Hazelnuts are rich in protein and unsaturated fat. They also contain significant amounts of manganese, copper, vitamin E, thiamine, and magnesium. The leaves are used to stimulate circulation and bile production, and they are used for liver and gall disorders (Alfrey, 2017). The hazel wood is white-reddish, easy to work being soft and flexible and is utilized I the production of coverings. The cotyledons of the fruits are very oleaginous. By pressing them, edible oil is produced, that has pleasant taste, utilized also in the cosmetic industry for its emollient properties. The leaves and the bark contain tannins and resins, substances to which are recognized a stringent, anti-inflammatory, antipyretic and depurative properties. The presence of the hazelnuts, also if in traces, is to be shown, as required by law, on the food labels, as it can be cause of alimentary allergies. The Common hazel is widely cultivated for its fruits, much required by the confectionary industry (https://www.monaconatureencyclopedia.com/corylus-avellana/?lang=en).

3.3.3 Elaeagnus multiflora (cherry)

Part I: General aspects

Classification:

Scientific name: *Elaeagnus multiflora*

Common name: cherry elaeagnus, cherry silverberry, goumi, gumi, or natsugumi

Family: Elaeagnaceae

Figure 3.23 General morphology of the cherry flowers and fruits

Origin and distribution:

Cherry silverberry (see also Figure 3.23) is a native plant to China, Korea and Japan (Bieniek et al., 2017). Also, it is cultivated at many countries in small scale such as Australia, USA, North Africa and Europe (Belgium, France, and United Kingdom). The Cherry silverberry is not wide distributed in Africa and can be found in some countries in Africa and North Africa (PFAF, 2020).

Production levels:

The 5-year-old plants can yield 3-4 kg/shrub, while the old shrubs (over 20 years old) can yield up to 30 kg (Bieniek et al., 2017).

Description of the plant:

Elaeagnus multiflora is a deciduous shrub that reaches 2 m in length and the tree trunk reaches 30 cm in diameter with darkened brown bark. Its shoots are intensively covered in brownish red scales. Ovate leaves reach 30 cm in long with 2-5 cm vast, the upper part of the leaf blade is green, while its bottom side is silvery. It grows best on dry, sandy and poor soils (Janick and Paull, 2008; Bieniek et al., 2017). The flowers of the plant are found separate or in pairs on the leaf axils. The plants bloom in spring (April-May) with fruit appearing in summer. The plant is cultivated to consume its edible fruits or for ornamental purposes.

Climatic requirements:

The cherry silverberry is a plant of low frost resistance, it can withstand temperatures down to about -20°C without damage when dormant (Phillips and Rix, 1989). Also, it can tolerate the growth at maritime (salty sea air) exposure

Soil requirements:

It can grow in varied soil types including loam, clay, rich clay, sandy and poor soils while it is preferable growing in good-drained soil and it can grow in different pH ranges from alkaline to acidic. Shaded or semi-shaded soils are suitable for growing. This tree is considered as resistant to low irrigation, to maritime exposure and pollution (Bieniek et al., 2017).

Part II: Cultivation practices

Propagation:

Cuttings of half ripe wood with heel is the method of vegetative propagation that is used to propagate cherry silver berry plants which can crop in 4 years when using cuttings method (PFAF, 2020). In addition, it can be difficult to propagat by seeds since it takes two years or more to germinate. Mature seeds are well sown in cold area; they will germinate at the end of winter or at the beginning of spring lasting about eighteen months. The first four weeks are for warm conformity and then the following twelve weeks are for cold conformity that helps in germination.

Soil preparation:

Soil tillage improves the soil conditions, as it is important to maintain relatively smooth, level ground for orchard work and harvesting. Organic matter can be added to the soil in order to improve the soil properties in cases of poor soild. However, cherry silverberry roots have the ability of nitrogen fixations (convert molecular nitrogen of the air into nitrogenous compounds in soil, so it can be planted in poor soils (Bieniek et al., 2017).

Planting:

It can be planted as shrub in orchards 12-15 feet apart, or in a hedge as ornamental plant.

Fertilization:

Cherry silverberry plants can grow in symbiosis with the action bacterium Frankia in the soil. This bacterium is responsible for atmospheric nitrogen fixation, transforming it in to an accessible form for the plant, and indirectly for other nearby plants.

Irrigation:

Cherry tree has a moderate need for water.

Disease control:

The plant and fruit appear to be resistant to diseases and pests (Horst, 1990).

Harvesting:

The shrubs of tree hide fruits; therefore it is not easy to collect them w (PFAF, 2020). Berries can be harvested by shaking the shrub and collecting the berries on a sheet below. As this can be hard and harmful to the plant, attention must be paid not to damage the tender young shoots. Ripeness of the berries is obvious as the colour turns deep scarlet (with less acidic flavor) and in that stage the harvesting is also easier a deep scarlet color and not as acidic in flavor (Baessler, 2018).

Part III: Postharvest handling

The fruits have not experienced commercial success as they are too delicate to transport fresh without damaging them.

Part IV: Utilization

Collection of fruits should be carried out carefully to avoid damage of young branches (Huxley, 1992). The plausible fruits are mature fruits because of astringent taste of unripe fruits. Fruits are rich in seeds; these seeds are fibrous and can be eaten as raw or cooked (Simmons, 1972; Bean, 1981; Kunkel, 1984).

Concerning the chemical composition of the cherry silverberry fruit: They are rich in minerals and vitamins including E, C and A, in addition to carotene, phenolic compounds, amino acids as well as essential fatty acids (Shin et al., 2008). Beneficial for halting or reversing the growth of cancers, coughs, watery diarrhea and reduce cholesterol as mentioned at (health benefits times) electronic site. Lee et al. (2010) mentioned that they include also substances that have antioxidant, anti-inflammatory and anti-proliferative effects and could be of crucial importance in treating colon cancer.

3.3.4 Hippophae rhamnoides L. (sea buckthorn)

Part I: General aspects

Classification:

Scientific name: *Hippophae rhamnoides* L

Common name: sea-buckthorn , Siberian pineapple

Family: Elaeagnaceae

Figure 3.24 General morphology of the sea buckthorn fruits

Origin and distribution:

Sea buchthorn (see also Figure 3.24) is native to cold regions in Asia and Europe as Poland, Germany, Baltic coasts of Finland (Biswas and Biswas, 1980; Kluczynski, 1989), United Kingdom and Bothnia in Sweden (Baker, 1996) whereas in Asia it could be founded in Nepal, Bhutan, India, Afghanistan and Pakistan (Rousi, 1971) and recently founded in Canada, USA, south Korea Bolivia, Japan and Chile (Li and Beveridge, 2003).

Production levels:

Yield data for sea buckthorn is scarce, since most fruit collection is from natural habitats, plantations for controlling soil and water erosion, and field shelter belts. In Germany, a yield of 5 t/ha was reported from an orchard plantation. It was estimated that an orchard with 4,000 trees/ha and a 1:6 male and female ration, should yield approximately 10 t/ha (Varlamov and Gabuniya, 1990).

Plant Description:

It is deciduous, hardy and evergreen shrub. It grows up to 4 m tall. The first flowering mostly occurs after three years. To allow fertilization and fruit production, male plants must be planted near the female plants (Li and Beveridge, 2003).

Climatic requirements:

This plant is detected at varied temperature from -43 up to 40°C while vegetation needs 5-7°C. Flowering needs 10-15°C and needs to remain at 14- 18°C until harvesting time (Dobritsa and Novik, 1992)

Soil requirements:

It can be grown in great range of soil types. Light structure soil type is suitable with rich nutrient at pH 6-7.5. It is suggested to apply hardness in deep dormancy time, November to December and in January to March at post time of dormancy. Phosphorus is essential for this plant while it requires little nitrogen (as it can fix nitrogen), (Cristian, 2014).

Part II: Cultivation practices

Propagation:

As the plant is diocious, seed propagation is not usually used in orchard. Excess male plants should be replaced with females. Cuttings will bear fruit 1 to 2 years earlier than seed propagated trees. Soft wood or hard wood can be used in cutting as well, as suckers and layering (Synge, 1974).

Planting:

Plants produced from seeds at the age of 4-5 years old start their fruiting stage whereas peaks will be at 7-8 years, and they remained active until 30 years in case of care pruning. The best time for cultivation is spring (Stobdan et al., 2010).

An orchard planting can yield 10 tonnes of berries per hectare. A wide variety of seeds is suggested at linear planting spacing of 1 m within the row and 4 m between the rows. South-east sloping terrain is recommended to facilitate the maximum daylight publicity and rows ought to be oriented in a north–south direction to provide maximum light (Stobdan et al., 2010).

Fertilization:

Application of 600 to 800 kg·ha^{-1} of calcium superphosphate plowed deeply into the soil has been recommended for sea buckthorn (A. Bruvelis, personal communication). Garanovich (1995) reported that, in Belarus, a single winter top dressing with mineral fertilizers 100N–200P_2O_5 –100K_2O (kg·ha^{-1}) improved fruit size, yield, and quality. Martemyanov and Khromova (1985) indicated that best growth was obtained by applying peat compost at 60 t·ha^{-1} and 50 kg·ha^{-1} each of N, P_2O_5, and K_2O. In Siberia, 5-year total fruit yield increased by 23% when N, P_2O_5, and K_2O at 60 kg·ha^{-1} each were applied to a black calcareous soil (Predeina, 1987).

Irrigation:

In case of low rainfall (400 mm), irrigation is required (Synge, 1974). It is considered drought resistant but it is susceptible especially in spring at flowering while young fruits are starting developing. In arid area, planting is possible with water supply. It can bear fruits at altitudes up to 2,000 m above sea level.

Disease control:

Holotrichiaoblita, Gryllotalpaunispina and Agrotissegetum are the main underground pests in nurseries, attacking young roots of Sea Buckthorn. These can be controlled with poisonous baits and lamplight luring. Holcocerusarenicolus is another root boring Cossid (Stobdan et al., 2010).

Other cultivation practices:

Pruning and training branches promote growth and facilitate harvesting. Pruning should be started the same year that the trees are planted and the preferable time is late winter.

Harvesting:

The fruits ripen in the fall and frequently cling on the shrub until the following March/April. In Asia the fruits are harvested by hand. Different mechanical harvest methods such as shaking, vacuum and quick freezing are developed. Mechanical harvesting also exists– with the sequence of cutting a branch from the tree, freezing it, and then shaking the branch to release the berries. When the fruit is frozen on the shrub, a trunk clamp-on vibrator harvester may be used but with this method an additional step of berry cleaning is necessary (Varlamov and Gabuniya, 1990).

Part III: Postharvest handling

Sea buckthorn berries carry a strong musky odor with rancid taste when overripe, detectable even in the field. Washing may reduce or change the odor (Beveridge et al. 1999). To avoid this problem, berries must be harvested at the correct stage, quickly transported to the processing plant, and be cooled immediately to temperatures around 4 to 6°C to retard growth of microorganisms. If the berries are to be stored more than a few days, they should be frozen, preferably by individual quick freezing techniques. The berries are thawed and processed to products as required on demand. Juice extracted by pressing or centrifugal techniques must be stored under refrigeration and requires pasteurization and freezing for long term storage. Alternatively fruit may be processed into pasteurized or sterilized finished products and stored in that form at room temperature. The shelf life even of sterilized product is limited but improved in refrigerated storage. After harvest, the berries should be placed in shaded area in flats no more than 15 cm deep. Pre-cooling for storage is advisable if high temperatures (more than 20°C) occur at harvest, especially if breakage occurs at harvest and before cleaning. Fresh market berries, after cleaning, should be delivered and sold within five days. Imperfect fruits or those that have bruising damage can be used for processing (jams, nectars, chutneys, etc.). If immediate processing is not possible, then quickly freeze the fruits, and keep them at -18°C until required in processing. Seabuckthorn does store very well this way. Thaw and allow to warm up to 16 or 18°C before processing.

Part III: Utilization

Both the leaves and the fruits can be used. Fruits are used in industrial foods, in folk medicine and cosmetic industries whereas leaves are used in feeding of ruminants or for shelterbelt (Stobdan et al., 2010). Generally, all parts contain varied phytochemicals and nutrients. Fruits include high amounts of vitamin C as compared to orange and lemon. Fruits are used in food industries for jam and juice. They are also used for creams and shampoos or massage oil while dried leaves can be used as tea (Li, 2002).

Hippophaer hamnoides is widely used in traditional medicine, particularly in Russia and Northeast Asia. The leaves are used as herbal medicine for various disorders. *H. rhamnoides* fruits have also been used in traditional Austrian medicine as tea, juice, or syrup for treatment of infections (Li, 2002).

Hippophae rhamnoides is used for feeding livestock. The pomace from processed *H. rhamnoides* fruit can be used as animal feed, such as for poultry feeding (Stobdan et al., 2010).

3.3.5 Lycium barbarum (goji berry)

Part I: general aspects

Classification:

Scientific name: *Lycium barbarum*

Common name: the wolfberry or goji berry, Chinese wolfberry, Chinese boxthorn, Himalayan goji, Tibetan goji, mede berry, barbary matrimony vine, red medlar or matrimony vine

Family: Solanaceae

Figure 3.25 General morphology of the goji berry fruits and leaves

Origin and distribution:

The goji berry (see also Figure 3.25) is widely distributed in the arid and semi-arid regions of China, Korea, Japan, Europe, North America, and the Mediterranean.

Production levels:

Currently, China is the largest world producer with its 82,000 ha of cultivated land and 95,000 t of berries produced per year.

Description of the plant:

Lycium barbarum is a deciduous woody perennial plant, growing 1–3 m high. The tree has weak arching branches, and the side branches are often reduced to short leafless spines. L. barbarum leaves form on the shoot either in an alternating arrangement, or in bundles of up to three. Each leaf is green, scarcely fleshy when fresh, usually lanceolate (spearhead-shaped), sometimes with rounded tips. Clustered leaves are up to 25 mm long; the single alternate leaves are up to 55 mm long.

The flowers grow in groups of one to three in the leaf axils, with pedicels 6–15 mm long. The calyx, eventually ruptured by the growing berry, is a whitish tube crowned by five or six radial triangular sepals, shorter than the tube, 10–12 mm long and 3–4 mm wide, sometimes 2–lipped, strongly curved. The sepals are whitish on the lower side (facing towards the branch) and deep mauve on the top side. Each flower has five stamens, exerted for 3–8 mm, with stalks longer than the anthers. The pistil is 8–11.5 mm long. The anthers are longitudinally dehiscent. The fruit of *L. barbarum*, the main variety of goji berry, is a bright orange-red, ellipsoid berry 1–2 cm (0.39–0.79 in) in diameter. The fruiting calyx is split deeply once or twice. The number of seeds in each berry varies widely based on cultivar and fruit size, ranging from 10 to 60. The seeds are about 2 mm long, 1 mm wide, yellowish, compressed with a curved embryo.

Climatic requirements:

The flowers do not set fruit over 29°C. Goji berry plants will need late afternoon shade in high temperatures. Otherwise the fruit crop is substantially reduced.

Soil requirements:

It grows in moderately fertile, well-drained soil in full sun and can be grown as a hedge. The soil should be well drained, low in organic content, with recommended pH range 7.0-8.2 (neutral to alkaline).

Part II: Cultivation practices

Propagation:

Seeds, cuttings of half-ripe wood or cuttings of mature wood and Division of suckers could be used for propagation.

Planting:

Seeds are sown early spring in a greenhouse. Germination is usually good and fairly quick. The seedlings must be pricked out into individual pots when they are large enough to handle and is suggested to be grown in the greenhouse for their first winter. Late spring or early summer is the planting period. Shoot tips of the young plants must be pinched out in order to encourage bushy growth (Cooper and Johnson, 1984). Cuttings of half-ripe wood, 5-10 cm can be also used with a heel if possible, and these should be planted in July/August in individual pots in a frame with good percentage of successful rooting (Cooper and Johnson, 1984). Cuttings of mature wood of the current season's growth are also used, planted in autumn to late winter in a cold frame.

In addition, this plant can grow in containers of 5 gallons (ca. 18.9 L) and more that drain well. In hot, dry climates, it may fruit better in a container that is protected from wind. The plantation shoud be done in spring after the last frost. When they are in the ground, they can be grown on a fence, trellis or stake so the plant is more manageable. 3-4 inches (ca. 7.5-10 cm) space is needed between plants and 6-8 inches (ca. 15-20 cm) between rows if growing more than one.

Fertilization:

The use of organic fertilizers that are low in nitrogen and higher in phosphorous are suggested for *Lycium barbarum*. High nitrogen results in all foliage and no flowers and no fruit in most nightshade plants.

Irrigation:

Lycium barbarum is drought tolerantbut a lack of water may result in the loss of the fruit crop.During the first Year if the plant is in a container, the soil moist must be kept by watering daily. If it is in the ground, watering must take place every 1-2 days for the first two months and in the hottest part of summer when there is no rain. Deep watering encourages deep root growth and reduces the need to water frequently after four months. Do not fertilize until the second year.

Disease control:

Can suffer from powdery mildew

Other cultivation practices:

Mulch is needed to reduce heat stress on the roots and retain soil moisture in summer.

Regarding pruning, it is suggested not to prune the first winter. After the first year, lateral branches can be trimmed by half to encourage new growth.

Harvesting:

Its harvest period begins in August and lasts till October (Zhang, 2013). The size of *Lycium barbarum* fruits is about 1-2 cm and its color is bright orange-red (Bruno, 2009). Taste and ripening of this fruit are determined by the sugar and organic acids in it. Sugar and organic acids are also important factors in determining the organoleptic properties of the fruit (Mikulic et al., 2012). The fruits are ripe when fully red. Harvesting is done by shaking each branch so the ripe berries fall onto a tarp on the ground. Touching the berries should be avoided in order not to oxidize the fruit (which then turns black).

Part III: Post-harvest handling

Storage after harvest: Unwashed berries can be refrigerated for one week or more. Once washed, they can be eaten fresh or frozen. Drying at higher temperatures destroys nutrients.

Part IV: Utilization

Lycium barbarum L. fruit is used as a traditional Chinese herbal medicine and functional food in daily life (Amagase and Farnsworth, 2011; Wu et al., 2018). As a food, dried wolfberries are traditionally cooked before consumption. They are also used as herbal tea, as well as in Chinese soups, or in combination with meat and vegetarian meals. Goji fruits are also used for juice, wine and tincture (Gross, 2006; Amagase and Farnsworth, 2011; Benzie and Wachtel-Galor, 2011; Potterat, 2010). *Lycium barbarum* is generally dried and then consumed. When dried, it looks like raisin. It is added to tea, alcoholic beverages, soups, yoghurt, vegetable and meat dishes, rice gruel, and porridge. There is a great demand for its juice and jelly in many countries because of its easier consumption in these forms. Fruit has been used for its curative properties in Chinese medicine for more than 2300 years (Sze et al., 2008). *Lycium barbarum* is very beneficial uses for human body, such as anti-aging, preventing tumor development, regulating immune system, improving visual sense, and protecting against cancer (Redgwel et al., 2011). Researchers have found records of ancient botanists stating that *Lycium barbarum* heals kidneys and increase the luster in eyes, and they have also highlighted that antioxidant activity is the source of these protective effects (Redgwel et al., 2011; Endes et al., 2015). Besides its vitamin and mineral content, *Lycium barbarum* is the focus of attention for its polysaccharide, betaine, lutein, and zeaxanthin content (Endes et al., 2015). A wide range of health benefits, including cancer prevention and treatment, have been claimed for lycium.

3.5.6 Ribes uva-crispa (gooseberry)

Part I. General Aspects

Classification:

Scientific name: *Ribes uva-crispa*

Common name: gooseberry

Family: Grossulariaceae

Figure 3.26 General Morphology of the gooseberry fruits

Origin and distribution:

European gooseberry (see also Figure 3.26) is native to Great Britain south and east to the Caucusus region. The species is found naturalized in scattered locations such as in alpine thickets and rocky woods in the lower country, from France eastward, into the Himalayas and peninsular India.

Production levels:

Gooseberries have been cultivated in Europe since the beginning of the 17th century. Although their popularity has declined in recent years, they are still widely used as fresh fruit and in the preparation of desserts, juices and jams. In countries like Germany, Russia, Poland or Scandinavia, gooseberries are grown on large commercial plantations.

Description of the plant:

Ribes uva-crispa, commonly called gooseberry, is erect, spiny, deciduous shrub which is primarily grown for its edible berries. *Ribes uva-crispa* is growing from 1 to 1.2 m.

Climatic requirements:

This plant can be cultivated facing the north and eastern. The northing plant fruit will take more time to mature which cause expanding of season and it'syield will be less. Hot weather is not preferable for this plant andyoung fruit and flowers are considered sensitive to frosts while the plant is considered sensitive to lack of potash when it was grown in alkaline medium. It is usually cultivated in varied regions as it used in feeding and has many varieties names. Birds prefer this plant; therefore, it needs protection from damage by them. When the fruits are fully mature they can be damaged by birds. The best weather conditions for plant growing are cold and moist as it is found in north Europe. The best yield and fruit quality are produced after two years of planting; therefore, clipping is required to enhance new and young shoots (Thompson, 1878; Facciola, 1990; Arnberger, 1986).

Soil requirements:

Varied soil types are suitable for growing the plant but it prefers good-drained and moist soil with different pH medium, neutral, alkaline and acidic and it can be cultivated in shade and semi-shade positions (Huxley, 1992; Bean, 1981).

Part II. Cultivation Practices

Propagation:

Goose berries are mainly propagated by hardwood cuttings. The rooting frequency, however, is usually rather low and the percentage take is disappointingly small. Production by layering the shoots is possible but not recommended as this technique gives a bush without suitable straight stem. For these reasons and also for pathogen elimination, incorporation of the in vitro technique is particularly significant. Semi-mature wood must be used in the preparation of cuttings in middle summer with heel, 10-15 cm in length (Sheat, 1948 & Dirr and Heuser, 1987). In autumn, seeds become mature and it is preferable to be sown in winter, cold conditions. Seeds need three months for conformity at 0 to 5°C and they should be sown as early as possible (Dirr and Heuser, 1987; Bird, 1990).

Soil preparation:

Organic matter such as compost, peat, or manure must be added to the soil to improve the soil properties, especially for sandy soil.

Planting:

Gooseberries are often planted at the density of 2.5 x 1.0 m. In Canada and the USA, gooseberries are planted in the pick-your-own operations using different spacing, depending on the equipment and the training system. (Stanislaw, 2018).

Fertilization:

Goose berries plant is considered as potash lacking sensitive (Chittendon, 1956), so it’s cultivation in alkaline soils needs further attention. Gooseberry plants are heavy nitrogen feeders. To give the plants a healthy start, addition of manure is suggested into the soil before planting. Annual top-dressings of composted manure are beneficial as well. If plants are not vigorous, lightly broadcast about 0.25 to 0.5 pound (ca. 113 to 226 g) of 10-10-10 per plant. Fertilizers containing muriate of potash (potassium chloride) should be avoided (http://www.hort.cornell.edu/fruit/mfruit/gooseberries.html).

Irrigation:

For quality fruit, from bloom to the end of harvest, gooseberries require about one inch of water per week. In most areas, rainfall is usually adequate, especially if mulch is being used. However, if rainfall is short, supplemental irrigation is advised. Drip or trickle irrigation is preferable to overhead irrigation, which can increase foliar disease problems. During prolonged dry periods after harvest, plants should be watered periodically until late August or early September. Add enough water to moisten the soil to six to eight inches, allowing it to dry before watering again. Roots can be injured by over-irrigation.(Anthony Bratsch and Jerry Williams)

Disease control:

Powdery mildew: In early summer, a whitish, powdery growth appears on the surface of leaves, shoots, and branch tips. If left unchecked, the fungus can progress to the berries themselves. Warm, humid conditions with poor air circulation favor powdery mildew. Some homeowners are experimenting with trellising gooseberries because it improves disease management and harvest ability. Some horticultural oils applied at first sign of mildew can prevent spread.

Anthracnose and leaf spot: These diseases can become serious problems, especially in wet, humid years. Symptoms range from brown spots and yellowing on leaves, young shoots, and stems to early defoliation.

Harvest:

This plant is harvested when 20% of the fruit are evaluated to be ripe. Harvest dates vary from 15 June to 8 July. Fruit color changes with fruit size, especially for the red cultivars. Selecting fruit on the basis of firmness and color rather than fruit size is the best indicator of fruit sweetness and therefore consumer acceptability. Light crops are usually developedthe second year and a full crop by the third. Berries do not drop immediately upon ripening, so they usually can be harvested in one or two pickings.

Other Cultivation Practices:

Gooseberries should be pruned when the plants are dormant, in late winter or early spring. Branches that lie along the ground should be removed as well as branches that are diseased or broken. Fruiting is strongest on spurs of two and three year old wood.

Mulch keeps the soil cool in the summer, retains moisture, and controls weeds. So, 2 to 3 inches of mulch should be spread around plants every yearly. Suitable mulches include straw, lawn rakings, composted manure, compost, wood chips, or similar materials. Grass clippings make excellent mulch.

Part III. Post-harvest Handling

Berry fruits are classified into three classes, as follows:

1-"Extra" Class Berry fruits where fruits must be of superior quality.

2- Class I Berry fruits must be of good quality.

3- Class II where berry fruits that qualify satisfy the minimum requirements (UNECE STANDARD FFV-57, 2017).

Berry fruits must be packed in order to be protected. In order to avoid fruit hazards that can be produced by packing, packages should be cleaned very well from foreign substances before packing (UNECE STANDARD FFV-57, 2017).

Gooseberries have a high potential for fresh market sales for a few different reasons: gooseberries are said to be the most shelf-stable berry handled commercially. Some customers might be reluctant to purchase a fruit they're not familiar with, so having free literature describing the fruit and its uses can be helpful (Ames and Greer, 2010).

Part IV. Utilization:

Gooseberries are edible. They are used in deserts, to flavour beverages such as sodas, waters, or milk, or to produce fruit wines and teas. Gooseberries can be preserved in the form of jams, dried fruit, or as the primary or a secondary ingredient in pickling, or stored in sugar syrup.

The biological activities of fruit juices and pomace (skin, seeds) extracts from blackcurrant (Ribes nigrum), gooseberry (Ribes uva-crispa) and their hybrid plant (jostaberry, Ribes × nidigrolaria) were evaluated against the most frequently isolated twelve human pathogenic Candida species by broth dilution tests. The phenolic content of juice, water and methanol extracts were measured and the relationship with antifungal activity was assessed. Growth of the most Candida species was inhibited, with the exception of *C. albicans*, *C. krusei*, *C. lusitaniae* and *C. pulcherrima.*. R. nigrum, with the highest phenol content, is observed to have the highest anticandidal activity, indicating a positive correlation between phenol content and antifungal activity (Krisch et al., 2008).

3.3.7 Rubus fruticosus (blackberry)

Part I: General Aspects

Classification:

Scientific name: *Rubus fruticosus*

Common name: Blackberry

Family: Rosaceae

Figure 3.27 General morphology of the Blackberry plant and its berries

Origin and distribution:

Blackberry (see also Figure 3.27) is considered to have originated in Armenia, but is distributed in Asia, Europe, south & north America and Oceania (Swanston et al., 1990; Pullaiah, 2003; Ahmad et al, 2006). This genus is widespread all over the continents with one exception, Antarctica (Weber, 1995). It is limited on mountain in tropical and sub-tropical area and it is not presented in east Africa (Luke Q, National Museums of Kenya, personal communication, 2004). *R. fruticosus* is considered common species.

Production levels:

In some regions, like New Zealand and Australia is considered as weed while for some other countries is a preferred fruit crop (Groves, 1998)

In Australia, production loss by impacts of blackberry was determined at $42 million (Field and Bruzzese, 1984). The yearly economic benefit was determined by about $660,000 from fruit production Blackberry thickets may also have passive economic impacts through forming dense barriers limitation the movement of livestock, and the thorny stems which can cause injury to animals and contaminate wool.Description of the plant:

Rubus fruticosus L. is a semi-prostrate to almost erect, scrambling, perennial deciduous prickly, shrub with entangling and arching stem growing up to 3 m at a fast rate. It grows in woodland garden sunny edge, dappled shade, shady edges (Plants for a Future, 2012). This bushy plant is thorny, but some cultivated varieties are free of thorns. Blackberries are perennial, lasting for three seasons or more (Hummer et al., 2007). Plants typically bear biennial stems or semi woody called canes. They vary from sprawling to almost erect, spreading shrubs with thorn and leaves, the stem grows up to 7 m in length that is greenish, purplish or red in colour. Every spring buds of the woody root produce juvenile canes which grow at a fast pace of almost 50–80 mm per day (Hummer et al., 2007). They are categorized into two groups in terms of branch structure: generative cane (floricane) and vegetative cane (primocane). Vegetative canes formed during first year convert into generative canes during the second year (Eyduran et al., 2008). The plant flowers in early summer and late spring. Diameter of a flower is about 2–3 cm having 5 pale pink or white petals. Flowers have multiple stamens. After fall of petals, fruit develops an aggregate of drupelets that are green earlier and later turn to red to black on ripening (Muhammad et al., 2014).

Climatic requirements:

Generally, is considered a temperate species that prefers a range of rainfall and soil conditions. In Australia, it is presented on temperate climates that have at least 700 mm annual rainfall (Bruzzese, 1998). It grows in USA reaching up to 1;600 m (Ertter, 1993). The plant can tolerate strong winds while it is sensitive to maritime (Bean and Clarke, 1991; Huxley et al., 1992).

Soil requirements:

Rubus fruticosus L requires moist soil but can tolerate some drought, or even areas with extreme aridity (Weber, 1995).It is easily grown in a good well-drained loamy soil (Chittendon, 1951; Bean, 1981; Huxley, 1992) and thrivesin acid and calcareous soils (Beckett, 1979) but canolerate poor soils as well(Davis, 1990). Established plants are drought resistant.

Part II: Cultivation Practices

Propagation:

Seeds can be germinated in spring. Seedlings considered weak competitor so instead huge amount of annual seeds are used. Weed competition and exposing to shade affect survival of seedlings passively. Fifteen percent of seedlings can survive yearly (Amor, 1971) which can be developed to four canes (to 1 m) and produce daughter at their first fall season. The vegetative growth from canes can be established only if their roots are able to contact soil. It can also be produced by pollination by insects. The thickest Crowns are those that reach seven years old (Amor, 1971; Bruzzese, 1998).

Soil preparation:

Before planting, the soil should be tested as pH, potassium, phosphorus, magnesium, calcium, and boron. If soil test results indicate that the soil pH is below the optimal pH range of 6.0 to 6.5, an acid neutralizer should be applied such as calcite or dolomite lime in order to increase soil pH but a year before planting. If the soil pH is above 7.0 sulfur should be used to effectively reduce the pH to the ideal range for brambles (Raspberry and Blackberry Production Guide, 2008).

Planting:

The plantation can take place from October to March with suckers in bare roots, and until May for plants in containers. The mulberry likes exposure in the sun, but not scorching. It can withstand the semi-shade, especially if it is leaning against a wall that will keep it warm. Not very demanding, the mulberry doesn't like heavy lands - of course, it will not balk in a rich soil. The green shoots should be buried in a furrow 8-10 cm deep, ideally in a North-South oriented line. They should be planted by 1 m each, and 1.20 m equally between the furrows. (https://www.groww.fr/en/plants/blackberry).

Fertilization:

Current fertilizer recommendations for N fertilization of trailing blackberry, range from 25 to 45 kg/ha in the establishment year and 45 to 60 kg/ha in subsequent years. In 'Thornless Evergreen', experience in Oregon, USA has shown that mature plants can be fertilized with 55 to 70 kg/ha of N with good response. In erect (e.g., 'Navaho', 'Kiowa') or semi-erect (e.g., 'Chester Thornless', 'Triple Crown') blackberries, 25 to 45 kg/ha in the establishment year and 45 to 70 kg/ha in subsequent years is recommended in the USA (Hart et al., 2000; Pritts and Handley, 1982).

Every year the soil around the mulberry trees should be amended with a layer of compost, preferably before winter (https://www.groww.fr/en/plants/blackberry).

Irrigation:

An irrigation system should be in place and operational before planting brambles for two important reasons: (1) transplants need to be watered immediately, and (2) any pre-emergent herbicide applied after transplanting will need to be watered in by rain or irrigation to be effective (Raspberry and Blackberry Production Guide, 2008).

Blackberry trees do not require much watering, outside the first weeks of their installation, and of course if they are kept in tanks or in case of severe drought (https://www.groww.fr/en/plants/blackberry).

Disease control:

The most important pathogens on the canes are Septocyta ruborum (Purple blotch), Gnomonia rubi (Gnomonia canker) and Sydowiella depressula (Sydowiella canker). Pathogenic fungi of less importance on the canes are Elsinoë veneta (Anthracnose) and Coniothyrium fuckelii (Cane blight). Peronospora sparsa (Downy mildew) is the most important fungus attacking leaves. On fruits Botrytis cinerea (Grey mould) is the most prevalent pathogen. Cladosporium spp. (Cladosporium rot) and Penicillium spp. (Blue mould) are frequently observed on fruits, but did not seem to be of significant importance. Other minor fruit rots were due to Colletotrichum gloeosporioides (Bitter rot) and Mucor sp. (Mucor rot). Phragmidium violaceum (Blackberry rust) can be found on canes and leaves, but is of minor importance. G. rubi and S. depressula causes damage mostly in the thornless cultivars, and P. sparsa is found almost exclusively in the thornless cultivar 'Loch Ness'. Both thorny and thornless cultivars were damaged by S. ruborum. In greenhouses the major fungal problem is B. cinereal (Nordskog et al., 2003).

Harvesting:

Fruits harvested before the fully ripe stage may have a longer storage and/or shelf life than those harvested at the fully ripe or overripe stage. However, there is usually a compromise between flavor and storage potential. Fruits harvested at a less ripe stage are unlikely to develop the same intense flavor as fruits harvested at the fully ripe stage (Raspberry and Blackberry Production Guide, 2008)

Part III: post-harvest handling

Cold-pressed blackberry seed oil is an excellent natural source of dietary a-linolenic (about 35%) and about 55–58% linoleic fatty acid with high phenolic content, significant antioxidant properties and the antioxidative stability (Parry and Yu, 2004; Verma et al., 2014).

Prolonged storage of frozen berries may have some impact on the quality of the oils compared to the fresh sample. It is reported that free fatty acid content (FFA) and peroxide values (PV) increased in blackberry oil (BO) (from 1.18 to 3.54% oleic acid), results demonstrated that pomace, despite longterm frozen storage, is a good raw material for oil extraction, as its oil composition remains stable. Chemical characteristics suggested that oils are of high quality and a possible source of functional ingredients (Radocˇaj et al., 2014).

Part IV: Utilization

European blackberry plants are used for herbal medicinal purpose such as antimicrobial, anticancer, antidysentery, antidiabetic, antidiarrheal, and also good antioxidant. Blackberry plant (R. fruticosus) contains tannins, gallic acid, villosin, and iron; fruit contains vitamin C, niacin (nicotinic acid), pectin, sugars, and anthocyanins and also contains of berries albumin, citric acid, malic acid, and pectin.

3.3.8 Rubus idaeus L. (red raspberry)

Part I: General aspects

Classification:

Scientific name: *Rubus idaeus* L,

Common name: red raspberry, American red raspberry and European raspberry

Family: Rosaceae

Figure 3.28 General morphology of red raspberry shrub and fruits

Origin and distribution:

American red raspberry (see also Figure 3.28) is native in many continents; in North America (USA, Canada), in almost all of Europe, in Africa (Algeria), in Asia (Russia, Turkey, china, Caucasus, Japan) (USDA, 2019 b), and it is commonly cultivated in other temperate regions (Favorite, 2003).

In South Africa, the cultivation and production of American red raspberry is still in a small scale. The main production states in South Africa are Western Cape and the Free State (Kriel, 2019)

Production levels:

The world fruit production of raspberries is 812735 tonnes, and average yield is 6.87 tonnes. The top production countries are Russia, Mexico, Serbia, USA, Poland, and Spain. Europe as a continent has the largest raspberries production (FAOSTAT, 2017).

Total world production of raspberries was 812,735 tonnes, with Russia supplying 18% (146,377 tonnes). Other major producers were Mexico (14.8%), Serbia (13.5%), the United States (13.0%), and Poland (12.8%).

Description of the plant:

American red raspberry is a deciduous shrub that grows up to 1.5 m high with biennial stems. The leaves are pinnate compound consists of three to five leaflets. The flowers are white to greenish white, found single or in small clusters (short raceme inflorescence). American red raspberry is primarily pollinated by bees.

The fruit is red, rounded, edible, sweet but tart-flavored, and 2 cm long. It is produced in summer or early autumn and is an aggregate fruit that consists of numerous drupelets around a central core (Favorite, 2003).

Climatic requirements:

The optimal temperature for growth and development of American red raspberry is 18-25°C (Terekhina, 2009).

Soil requirements:

The American red raspberry prefers fertile, well-drained soil. It tolerates a wide range of soil pH and texture, it prefers the slightly acidic or neutral pH soils (5.6-7), and soils which contain enough quantity of humus and elements of mineral nutrition (Favorite, 2003; Terekhina, 2009).

Part II: Cultivation practices

Propagation:

Seeds can be used for propagation of the red raspberry plant, in addition to layering and cutting. Seeds need to be treated with cold stratification treatment for one month at 3°C before cultivation. While propagation by cuttings can be used, Cuttings should be propagated in a site out of full sun and sheltered from drying winds. The cuttings are 20 cm long of new growth shoots from late spring to midsummer (Favorite, 2003).

Soil preparation:

Site selection is very important as raspberries are susceptible to root rot, so it is better to cultivate it at well drained soils. In addition, plantations where tomatoes, potatoes, peppers or eggplants were planted the past 5 years should be avoided as they could host diseases such as Verticillium wilt (Berries for Africa, 2020).

Soil tillage improves the soil conditions, so it is important to maintain relatively smooth, level ground for orchard work and harvesting. Organic matter can be added to the soil in order to improve the soil properties enhancing the growth of the plants.

Planting:

After the seeds germinate, it is better to transplant it in separate pot for each plantPlant seedlings is transplanted in their permanent position in the late spring of the following year. The seedlings are transplanted 0.5-1.0 m between plants with a row spacing of 2.5-3.0 m (Favorite, 2003; Berries for Africa, 2020).

Fertilization:

Perennial plants have the ability to store nutrients from one season to the next. So, annual applications of nitrogen are needed to sustain good yields (Rempel et al., 2004). Many fertilization trials were conducted by Dale (1989) to determine optimum nitrogen (N) application rates for red raspberry. The results were highly variable with N application recommendations ranging from 50 to 340 kg/ha as mentioned). Red raspberry is N-limited, especially during periods of rapid growth (Kowalenko et al., 2000). However, over-application of N fertilizers is costly to the producer and may have negative effects on the environment and plant performance (Tisdale et al., 1999).

Irrigation:

Raspberries require irrigation from bloom through harvest to ensure good berry quality. It is better to avoid overwatering as raspberries are very susceptible to root rot. The new and young established plants require the most care to make sure that their roots do not dry out or get waterlogged. During the summer months, when the mature plant is growing and fruiting, about 20-30 mm of water is needed per week. This amount decreased during the winter season when the plants are in their dormant phase (Berries for Africa, 2020).

Disease control:

Orchard site selection andsoil preparation is very important for the successful growing of the plant. Cane blight caused by Leptosphaeria coniothyrium is a fungal disease that can infect the red raspberry plants andis characterized by forming Purple black cankers at wounds on young canes; cankers enlarge to encircle cane and cause wilting and death of lateral shoots, the rain splashes help in spreading the disease from infected to healthy canes. It can be controlled by avoiding over fertilization, and by pruning the plants at dry weather. Besides, the plants could be infected by Grey mold caused by Botrytis cinereal thatinfects the clusters, blossoms and fruits andthe fruits become mummified and covered in a grey powdery substance. Plantation of the raspberries in full sun and in an area with good drainage could prevent this infection; Also, the over fertilizing of plants must be avoided and the diseased berries must be removed in order to reduce inoculum.

Other cultivation practices:

Mulching is important throughout the season to conserve moisture and suffocate weeds. A thick layer of mulch should be kept surrounding plants at all times. Water of one inch per week should be applied from spring until after harvest. Regular watering is better than infrequent deep soaking. (https://www.almanac.com/plant/raspberries)

Pruning and trellising are important for American red raspberry. Many raspberry varieties are very vigorous and using a support system such as a trellis, which will help to protect the canes from wind damage while also support the weight of the fruit crop. The trellis should be constructed before or at planting to avoid damaging the young plants. Also, dead or damaged canes should be pruned out to enhance light and air penetration (Berries for Africa, 2020).

Harvesting:

The American red raspberries are harvested manually (Giovanelli et al., 2014).

All varieties will begin to produce fruit in their second season. In some cases, ever-bearers may bear small berries in their first autumn (https://www.almanac.com/plant/raspberries).

Part III: Postharvest handling

The fruits are collected at plastic containers. Then, theyare sorted and packed in plastic punnets. The postharvest life of red raspberries is limited to a few days (2–3 days from picking), mainly because of loss of firmness and susceptibility to fruit rot. This is due to their high respiration rate compared to other kind of fruit. The fruits stored at 4°C (Giovanelli et al., 2014).

They can be kept refrigerated for about 5 days. Raspberries can be also kept as frozen (https://www.almanac.com/plant/raspberries)

Part IV: Utilization

Rasberries have high nutritional value, as they contain vitamin C and polyphenolic compounds such as ellagic acid and anthocyanins. Moreover, their seed oil contains linoleic, a-linolenic, oleic and palmitic acids (Oomahet et al., 2000). A tea is extracted from the leaves and used in the treatment of diarrhea and as an aid in childbirth (Moerman, 1998). It is also known that the tea is used to relieve painful menstrual cramps. The leaves and roots are used as a gargle to treat tonsillitis and mouth inflammations, sores, minor wounds, burns and varicose ulcers (Brown, 1995). Europeans in the 17th century regarded the raspberries as an antispasmodic and they made syrup of the juice which they used to prevent vomiting (Readers Digest, 1990). In the 18th century physicians and herbalists deemed that the berries are useful as a remedy for heart disease. Red raspberries are eaten fresh or in jams and jellies, or added to pies and other baked goods, candies and dairy products to add flavor. Purple to dull blue dye is obtained from the fruit.

American red raspberry provides food and cover for many wildlife species. Grouse, birds, raccoons, coyotes, squirrels, skunks, and chipmunks eat the fruits. Raspberry thickets provide shelter for rabbits and squirrels and service as a nesting spot for many birds.

3.3.9 Mentha spicata (spearmint)

Part I: General aspects

Figure 3.29. General morphology of spearmint

Classification:

Scientific name: *Mentha spicata*
Common names: spearmint, common mint, lamb mint, mackerel mint and garden mint
Family: Lamiaceae

Origin and distribution:
Mentha spicata (see also Figure 3.29) is a native plant to Europe and south Asia. It is extended from Ireland at west to china at east. Additionally, it is naturally presented in North & South Africa and North & South America.

Production levels:
The production of *Mentha* species including the three species, *M. arvensis*, *M. piperita* and *M. spicata,* is considered one of the top twenty essential oils all over the world and it is estimated to be 7500 tonnes from 56,000 tonnes of all essential oil production. Spearmint world market essential oil production is estimated to be 1,500 tonnes yearly.

Description of the plant:

Spearmint, *M. spicata* L., is a perennial herbaceous plant, which growing up to 30-100 cm in tall. Stems are hairy to hairless and foliage. Rhizomes are fleshy widespread, they have square shape. Mentha leaves extended to 5-9 cm in long and width 1.5-3 cm with serrated margin. Spearmint flowers have cylinder spikes shape and 2.5-3 mm long with pink and white color.

Climatic requirements:

Spear mint cannot be grown profitably in tropical and sub-tropical areas, especially under very high summer temperature (41^{o}C). The ideal yield can only be achieved in humid and temperate conditions like Kashmir.

Soil requirements:

It is suitable and can be grown in different soil types. The best Mentha cultivation can be achieved with organic material and full sun exposure or partially shading areas. *Menth spicata* prefers wet conditions. It grows well in well-drained, rich in nutrient and organic soils. The appropriate pH range is between 6-7.5.

Part II: Cultivation practices

Propagation:
Germination of seed in spring can be described as quite fast. When plants are long enough to handle, seedlings can easily be transferred individually in separate pots until summer to be suitable for planting. Mentha plants couldn't be relied on to be breed true as they are sensitive to hybridization.

The seedlings are usually not uniform and their characters as the essential oil content always vary with or without hybridization. To get the same characters especially aroma, it is plausible to use a division in the Mentha crop, which can be carried out all over the year, but it is better to transfer it in spring or autumn, so as to give plants the opportunity for quick installation. The large division parts can be planted directly in the permanent cultivation areas. Any part of the root can be grown to produce a new plant, but for better extended cultivation, it is better to use a part with a length of 3 cm as much as the maximum length, then the part should be grown in a cold dark frame to be planted in summer season.

Soil preparation:

The soil must be plowed thoroughly before cultivation, and all the weeds or wastes of the previous crops must be removed.

Planting:

The preferable alternative seedlings production is float system; as it induces root length, root biomass, shoot part growth, percentage of survivals and subsequent growth after transplanting, while conventional cropping system affects seedling growth as it was documented for spearmint, organic fertilizers. Overall, Akoumianaki-Ioannidou et al. (2015) conclude that a float system can be used for the production of *Ocimum basilicum* and *Mentha spicata* seedlings under organic or inorganic fertilization. The soil for planting sections should be mixed with little amount of organic fertilizer as compost before planting. Watering sections or seedlings should not exceed three times weekly. Plants of spearmint should be placed at 90-120 cm in apart.

The preferred alternative seedling production is the flotation system; as it enhances root length, root biomass, shoot growth, survival rate and subsequent post-transplant growth, while the conventional cultivation system affects seedling growth as documented for spearmint, organic fertilizers. Overall, Akoumianaki-Ioannidou et al. (2015) concluded that a flotation system can be used for the production of *Ocimum basilicum* and *Mentha spicata* seedlings under organic or inorganic fertilization. The soil for planting sections should be mixed with a small amount of organic fertilizer as compost before planting. Watering sections or seeding should not exceed three times a week. Mint plants should be placed at a distance of 90-120 cm.

The appropriate planting method is then summarized in the following steps:

- Planting should take place in autumn or spring climatic conditions, while it is done in winter season in plains.

- Planting at late time always produce poor yield.

- The creeping horizontal stem of the plant should be cut into small pieces about 7-10 cm at 45-60 cm between rows to facilitate mechanical or manual applications. The planting is usually transferred to shallow furrows with a depth of 7-10 cm.

- The creeping horizontal stem of the plant is cultivated in the middle of the inner side of the ridges.

Fertilization:

At the time of new growth in early spring, supply the mint container with a balanced all- purpose liquid fertilizer. During the growing season, fertilizers should be applied every 4-6 weeks. Granular fertilizers should be applied in early spring after passing the frost dangers to enhance growth. Balanced fertilizer (16-16-16) should be applied about a teaspoon to the soil above the root zone in the first six inches of soil. Half tablespoon of all uses must be dispersed. It is recommended that mint avoid excessive fertilization and keep water away from leaves and stems to prevent rot and reduce the essential oil content that affects the taste of mint.

Akoumianaki-Ioannidou et al. (2012) investigated the production of peppermint and spearmint and concluded that the application of organic fertilizers to plants resulted in good roots (dry and fresh weight, length density and root surface) that facilitate transplanting. Excessive fertilization showed poor plant growth. The amount of fertilizers is determined according to soil analyses. To promote the growth of mint shoots, an additional dose of nitrogen fertilizer should be added after harvest during the growing season, while excess nitrogen affects the quality of the oil. Optimal performance can be achieved by applying compost.

Irrigation:

Drip and overhead irrigation is appropriate, but should not be over-watered.

The water needs of the mints are very high. Depending on the soil and climatic conditions, the crop is irrigated 6-9 times before the first monsoon. The crop requires three irrigations after monsoon.

Disease control:

Fungal diseases are common diseases in spearmint. Two main diseases are rust and leaf spot. *Puccinia menthae* is a fungus that causes the disease called “rust”. Spearmint leaves produce pustules that cause leaf fall down by rust infection produced by *Alternaria alernata.* This infection is appeared at the top of the leaf as dark spots. Many other fungi can affect spearmint as *Erysiphe cischoracearum, Rhizoctonia solani*, *Phoma strasseri* and *Verticillium dahliae.*

Some nematode diseases in spearmint include root knot and root lesions. Nematode species that cause root knots in this plant are various *Meloidogyne* species. The other nematode species is *Pratylenchus* which causes root lesions. Tobacco ring spot virus can also infect spearmint resulting in the disrupted development of plant and leaf deformity, while in areas such as China, spearmint infected with mosaic virus leads to leaf deformation.

Other cultivation practices:

After the winter, usually not much of the mint is left by some woody stems. The mint can be cut and the new shoots will start from the roots again. Minimal care is required for mint. Light mulch is used for outdoor spearmint plants that help in keeping leaves clean and soil moist with keeping regular watering. Pruning and piching are useful for spearmint.

Harvesting:

Investigation on suitable time for spearmint harvesting indicated that the highest yield in terms of fresh herbage, dry herbage and dry leaf was obtained when harvesting was done after full flowering stage. However, best essential oil percentage was obtained at full flowering stage (Kizil and Tonçer, 2006). Mint harvesting can be carried out three times in the growing season with keeping at least one inch of stem over ground level. Leaves can be picked as required.

Suitable harvesting items can be carried as follows; especially for locations where mint cannot give flowers:

- Generally the crop is harvested 100-120 days after planting when the lower leaves start turning yellow. If mint will harvest other times, the harvesting must be applied in bright sunny weather.
- Herb harvesting should be about 2-3 cm over ground level.
- 2-3 inches (ca. 5-7.5 cm) should be remained over the ground level during harvesting.
- After the first harvesting by eighty days, the second harvesting can be carried out.
- The first harvesting date may start at June to start the second at September.
- The production of mint fresh herb is approximately 48,000 kg/ha, whereas the average essential oil production of three cuttings per hectare is 50-70 kg/ha.

Part III: Post-harvest handling

Frequent harvesting is the key to keeping mint plants at their best. The first harvest begins in the spring. The best leaf flavor is presented by the younger leaves. Mint leaves can also be stored by cooling or air drying in bunch. It is also easy to grow mint indoors to get fresh leaves in winter and these leaves can be collected and dried in an airtight container before flowering.

Part IV: Utilization

The whole plant Mentha specata is considered as a carminative agent while leaves are commonly used as tea flavoring agent. Its essential oil as well as fresh and dried leaves is used in chewing gum, cosmetic, toothpaste, food, pharmaceutical industries, and confectionary (Bensabah et al., 2003). Shellfish and fish plates of Italian and Indian cuisine usually contain *M. specata.* In folk remedy, it is used as antispasmodic, carminative, antioxidant agent, antibacterial, diuretic, treating colds and flu, treating respiratory tract problems, hemorrhoids, antifungal, stomachache and gastric pain (Leporatti and Ghedira, 2009; Tawaha et al., 2007; Kizil et al., 2010; Tetika et al., 2013).

3.3.10 Morus nigra (black mulberry)

Part I: General aspects

Classification:

Scientific name:

Common name: black mulberry or blackberry (not to be confused with the blackberries which are various species of *Rubus*)

Family: Moraceae

Figure 3.30 General morphology of black mulberry

Origin and distribution:

Black mulberry (see also Figure 3.30) is naturally present in most countries of Western Europe and the East as China due to its edible use. It grows widely in North Asia, the South Caucasus region and Armenia and it is cultivated throughout Europe up to Sweden (Grieve, 1931). It was introduced to South America in the early 20th century and is listed in Parana as invasive (Biondi and Muller, 2013). It was reported that *Morus nigra also originated in* Mesopotamia and Persia mountain areas. It is known as *toot* by Persian, *shahtoot* and shajarat tukki in Arabic. Its fruit is used in making jam and juice called sherbets in Arabic region. In 17th century, black mulberry was introduced to Britain for silkworms, *Bombyx mori*, but the worm prefers white type of mulberry. The largest documented local concentration of black mulberry in Europe (470 trees) is in the Pukanec vineyards in Slovakia.

Production levels:

The yield is about 4-8 kg per tree and varies with the cultivar, age of the tree, agri climatic conditions and cultural practices.

Plant Description:

Morus nigra is considered to grow up to 12 m (39 feet) tall and 15 m (49 feet) wide. The leaves are 10–20 cm (4–8 in) long with a width of 6–10 cm (2–4 in) to 23 cm (9 in) with strong shoots, velvety on the underside, while the celestial surface is tough with stiff short hairs. The fruits of the plant reach a dark purple when ripe (2-3 cm in length). The Cluster has a rich flavor like Morus rubra and not like Morus Alba (white mulberry).

Climatic requirements:

The characters with the best growth can be obtained when the daily temperature is between 15-25°C, but can be tolerated 10-38 ° C. When inactivated, the plant can survive in temperatures down to about -5°C, but new growth can be severely damaged at -1°C. It prefers an average annual rainfall in the range of 700 - 1,500 mm, but tolerates 300 - 4,000 mm

Soil requirements:

Black mulberry prefers warm, well drained and deep loamy soils with good moisture holding capacity. Best growing characters are obtained with pH range of 6.5 to 6.8. Shallow soils are not recommended. Plants are very tolerant of atmospheric pollution.

Part II: cultivation practices

Propagation:

Seeds and vegetative propagation (cuttings, budding)

Soil preparation

Before planting, the soil should be plowed deeply, weighed and leveled. Pits of 1 x 1 x 1 m size are dug before the summer season at the recommended spacing.

Planting:

Cutting or seed production assays can be applied for black berry (Tyler, 2019). It is considered as a fast growing tree and requires light with suitable distances for growth (4.5 m in between trees) (Orwa et al., 2009). It is documented that these trees need more time for fruiting, about 15 years in UK (Fern, 2014). Fruits exposed to bleeding by cut. It is recommended to avoid heavy pruning by simply removing dead wood and thin branches. The pruning should be applied at the dormancy time, while the cut should not have a diameter greater than 5 cm (Fern, 2014).

In case of propagation by seeds, seeds collected after fruit ripening should be used after scarification. The planting of seedlings should be carried in early summer or late spring to cultivate in warm soil after ending of frosts. Black mulberry is one of the long-lasting trees, the tree can be revitalized during careful cultivation and pruning (Orwa et al., 2009).

Propagation of black mulberry by cuttings should be prepared from half ripe branches and then three quarters of its length shouldbe buried in the soil (Fern, 2014). It is reported that black mulberry does not propagate vegetative as easily as white mulberry (Tyler, 2019).

Generally, Black mulberries are planted at a spacing of 7 x 7 m that hosts 204 plants /hectare. The square system of planting is generally adopted. The pits are exposed to solar radiation for about 15-20 days and then filled with a mixture of topsoil (75%) and well rotten FYM or compost (25%). If planting is done with saplings, then one sapling is sufficient for each pit. Planting should be done during the spring season (February-March) or after the beginning of the monsoon season (June-July). Planting should be avoided during extreme winters or summers.

Fertilization:

In mid-winter, compost is added yearly while other fertilizers are not necessary in most cases except with dwarf trees. High nitrogen fertilizer supply should be avoided as it induces weak and rapid growth, which may be damaged by wind effect or freeze. Balanced fertilizers (10:10:10) is preferable to be used.

Black mulberries generally thrive with minimal fertilization. However, balanced fertilization will improve the performance and quality of black mulberry. It is recommended to incorporate FYM 10kg/tree. Tamil Nadu Agricultural University, Coimbatore recommended the application of NPK 50-50-50 g/plant to bearing trees. Fertilizers should be applied in February-March, when there is sufficient moisture in the soil. The exact amount of fertilizers to be applied will vary with the cultivar, vigor, age of the tree, planting distance, pruning, agro climate and soil status. Soil testing and leaf tissue analysis can help determine the precise requirement of fertilizers.

Irrigation:

Deep water or basin irrigation should be applied at least monthly during drought, but weekly during fruitin. Watering should be stopped in mid-November to encourage dormancy.

Black mulberries are drought resistant and should only be watered during droughts. However, regular watering during the growing season leads to better production of high-quality fruit. Basin irrigation at fortnightly intervals from February to May is recommended. Irrigation should be initiated before the application of manures and fertilizers. For uniform distribution of water and to avoid losses through seepage and conveyance, to reduce weed growth and to reduce dependence on labor, drip irrigation should be adopted in areas where water is scarce. Drip irrigation at 40-60%of pan evaporation using 4-6 drippers per plant from fruit setting to maturity (February to May) is recommended for optimum production. In the event of moisture stress, the fruit may fall off before ripening.

Disease control:

Black mulberry is sensitive to bacterial and fungal diseases. It extends more than the other mulberry species. Warm and wetted conditions encourage the infection.

Other cultivation practices

Organic leaves can be used, keeping at least one foot from the trunk, to reduce evaporation loss and soil temperature. The wet layer that touches the trunk causes fungal diseases.

Harvesting:

The "berry" is an aggregate fruit, with many small round fruits clustered together. Cultivar and ripe level controls its flavor, and the soil, sunlight and climate where the tree is grown. Black mulberry fruits have best tasting as compared to other mulberry species.

It takes two to three months for ripening of fruit. Berries ripen a few at a time on most cultivars. When berries are collected at their red color they will completed ripen to reach black color. Fruit of many cultivars completed its ripe on their tree to reach dull black from shiny black.

Exposing this tree to strong winds, trees can keep fruit for a day or two days whereas other mulberry species blow off as soon as they are ripe.

In other words, color change is the most widely used and most commonly used maturity indices for harvesting black mulberry fruits. Immature fruits are reddish in color, which turn black when fully ripe. Ripe fruits are characterized by an attractive shining surface and typical aroma. Black mulberry trees appear after eight to ten years of planting, but the economic yield is achieved from the 15th year onwards. The berries ripen in summer to late summer depending on the locality and the climate. The picking season is extended for three weeks. Fruits are harvested by spreading a sheet on the ground and shaking individual secondary branches. The harvest takes place in 2-3 days. Ripe berries that remain on the tree are picked by hand. The fruit should preferably be harvested early in the morning. The berries should be kept in a shady place to avoid creating too much heat in the field. Ripe berries are very fragile and should be handled with care as they tend to open easily.

Part III: Post-harvest handling

Fresh black mulberry fruit is very fragile and highly perishable. Packing and transporting them to remote markets is extremely difficult. The fruits are packed in flat and shallow containers of various types (cardboard, bamboo, paper trays) with one or two layers of fruits. The fruit must be sold within a few hours of harvest at the local market. Fresh fruit can be stored in a loosely sealed container and stored in the refrigerator for about a week.

Part IV: Utilization

This species has many recorded uses but is perhaps best known for its edible fruit. The juicy large fruit of the Black Mulberry has a sweet taste and a better taste compared to other species, such as Morus alba. It is used in the making of syrups, jellies and jams (Wiersema and Leon, 1999; Bircher and Bircher, 2000) and in the making of wine.

M. nigra is also used for various other uses: dead branches are useful as firewood, bark is used in Japan to make "artificial cotton" textile fibers, and wood is hard and water resistant and is used in furniture construction. The fruit and peel are used in the manufacture of cosmetics in India.

The fermented fruits are used in making alcoholic drinks in UK and Greece. Leaves, bark and fruit are used as dyestuff (Hanelt et al., 2001; Orwa et al., 2009; Lim, 2012). Commonly this tree used as ornamental and sometimes as indoor plants also as agroforestry, windbreak, shelter or shade tree and living fence (Orwa et al., 2009; Lim, 2012). *M. nigra* is used in traditional medicine in the preparation of ripe fruit syrup. Leaves of *M. nigra* are used as astringent, antipyretic and laxative.

Bark is used as anthelmintic and expels tapeworms. ecoction of leaves, roots and flowers are used to treat diabetes, sore throat and fever, whereas fruit juice is used to treat swollen vocal chords. On the other hand, black mulberry is used in treat gastrointestinal ailments and as antidiarrhoeal, laxative and prokinetic (Akhlaq et al., 2016). Additionally, its extract has inflammatory, antioxidant and analgesic, anticancer, antimicrobial, antifungal, skin-whitening, anti-hyperlipidemic, anti-atherosclerotic, anti-obesity, cardioprotective, cognitive enhancing, hepatoprotective, anti-platelet, anxiolytic, anti-asthmatic, anthelmintic, antidepressant, and immunomodulatory activities. The extract contains 20.9 mg/g dry weight flavonoids, cyanidin-3-O-rutinoside (2.9 mg/g) and cyanidin-3-O-glucoside (8.3 mg/g), (Chen et al., 2016).

3.3.11 Myrtus communis (myrtle)

Part I: general aspects

Classification:
Scientific name: *Myrtus communis*
Common name: bridal myrtle, myrtle (English); myrte, myrte commun (French); myrtos (Greek); mirto, mortella (Italian); mirta, murta, murteira (Portuguese); arrayán, mirta, mirto, mortera, murta, murtera (Spanish); Brautmyrte, Myrte (German); rihan, mersin (Arabic); tarihant, chilmoun (Berber); morta, mortula (Corsican); nertha, nerthe, nerto (Occitan).
Family: Myrtaceae

Figure 3.31 General morphology of myrtle

Origin and distribution:
Myrte (see also Figure 3.31) is native to Africa (Acores Islands, Algeria, Canary Islands, Eritrea, Ethiopia, Libya, Madeira, Morocco and Tunisia), Asia (Afghanistan, Cyprus, Iran, Iraq, Israel, Jordan, Lebanon, Pakistan, Syria and Turkey) and Europe (Albania, Bosnia-Herzegovina, Croatia, France, Greece, Italy,

Macedonia, Malta, Montenegro, Portugal, Serbia, Slovenia and Spain), where it mainly grows at the edges of the woods and in the thickets along the coasts.

Production levels:
Myrtus plants vary in their production from 10 kg to 200 kg/ha. In intensive Myrtus cultivation with 3000-3500 plant yields may reach four to six tonnes per hectare.

Description of the plant:

Myrtus is an evergreen shrub or is considered as small tree. It can grow to reach up to 5 m in height. The length of the leaves is about 2-5 cm, with aromatic essential oil. Its flowers are white or tinged with pink. The flower has five petals with several stamens protruding from flower. Ripe berries are blue-black.

Climatic requirements:
It is fairly resistant to the low temperatures, as it may resist up to about -6°C and, if well sheltered, to -9°C, but with damage to the foliage.

Soil requirements:
It is cultivable in fully sun condition or slight shade on soils of various nature, even if preferring those rather sandy, neutral or alkaline, well drained; it bears the saltiness.

Part II: Cultivation practices

Propagation:
It reproduces by seed, air layering and semi-woody cutting in summer.

Planting:

Pre-soak the seed for 24 hours in warm water and then sow it in late winter in a greenhouse. Seedlings should to be separated into individuals and placed in pots to facilitate grow and handling of them. They will stand in their green house for the first winter season. At the following late spring or early summer, plants can be transferred to their permanent places.

Half ripe wood is used for preparation of cuttings, 7-10 cm, in July to August. They have to be pot in a cold frame in fall and during winter. They shall be planted out in late spring. Cuttings of fully ripe wood, 7-12 cm with heel, kept under shaded area and frame free from frost. It will be planted out in early fall or late spring.

The seed should be pre-soaked for 24 hours in warm water and then sown in late winter in a greenhouse. Seedlings should be separated into individuals and placed in pots to facilitate their growth and handling. In late spring or early summer, the plants can be moved to their permanent places.

They can be planted in early autumn or late spring.

Practical Plants does not currently have information on propagation instructions of *Myrtus communis.* For planting, the hole should be dug to the size of a double-sized ball root with enough depth to be planted at the same level. In the case of poor soil, the digging hole should be wider and filled with compost.

The bush should be carefully removed from its container and then placed in the center of the hole. The surrounding area will be filled using original soil or compost-soil mixture and finally should be irrigated. The addition of organic matter is useful for cultivation in sandy soil and in very clay soil. This will help both the drainage and the water holding capacity. Suitable distances for cultivation are 1 x 3-3.5 m, it can produce 3,000 plants per hectare. The best time for cultivation is autumn or early spring. An annual plant from a nursery can also be used, since it can provide a first production already in the second year.

Fertilization:

Mostly, every few years the trees need fertilization and can be fertilized annually to maintain production. Avoiding fertilizers during the growing season is preferable. Soil analysis can help in this matter so as to evaluate the lack of any required nutrients. Nitrogen fertilizers will promote plant growth. The increase in stem growth will not allow it to harden before the onset of cold weather.

Irrigation:

The Myrtus plant cannot tolerate over moist condition in poorly drained soils, especially with increased humidity. Using a regular tree watering schedule during the first season can help the plant gain extensive rooting. This tree needs deep watering every month during the summer to prevent the plant from turning into yellow. The best results are obtained naturally with more frequent irrigation using micro-irrigation systems with shifts of 10-15 days depending on the availability and type of soil. Regular seasonal volumes may range from 1,000 to 3,000 m^3 per hectare.

Disease control:

Myrtus is sensitive to Phytophthora and Root Rot.

Leaf spot fungi: Bacteria and fungi can cause leaf spots in black or brown color and can be circular or rough and the yellow edge is appeared. These spots can be spread by insects, garden tools and insects. Removing infected leaves can help control it. Excessive irrigation can cause fungal spots or increase the spread of spots. The fungicide can help treat these signs.

Southern Blight:

Damage to the stem of the Myrtus tree or near the ground line is considered a sign of Southern Blight that can develop rapidly resulting in sudden and permanent wilting of the tree. This disease can increase with increasing temperature more than 29°C. This attack can infect large numbers of trees and survive for a long time.

Harvesting:

The fresh product is easily harvested by hand. Harvesting of fruits by machines remained limited. Although some producers have successfully marketed mechanical fruit harvesting in the fresh market, urrent harvesting and handling techniques generally cause excessive fruit damage to the fresh market. Myrtle berries are harvested in December when they are fully ripe, when they reach the highest concentration of anthocyanin (Mulas et al., 2013). For liqueur production, berries must be processed immediately after harvest to avoid overall quality. Myrtle fruit (*Myrtus communis* L.) is usually collected from spontaneous plants and used to produce the typical myrtle liqueur.

Part III: Post-harvest handling

For production of liqueur, the quality loss is associated with decomposition, weight loss, and growth without flavors. Gluconic acid is used an indicator of fruit aging (Angioni and Schirra, 2011; Mulas et al., 2013). Cold storage of myrtle fruit can prolong the processing period and, at the same time, avoid the immobilization of large sums of money from alcohol taxes, by storing infusions. The chemicals that reflect the quality of the myrtle can be preserved for only three months, while the content of anthocyanins and flavonoids will be significantly reduced, producing poor quality liqueurs. Very few articles are available in the literature on suitable storage conditions for myrtle berries. In addition, these studies focus mainly on the effects of storage conditions on berries and not on the relative hydro-alcoholic infusions used to make the liqueur. Myrtle berries are recommended cold storage for 3 months at 2 °C to maintain the quality of the fruit. In contrast, the total anthocyanin content is significantly reduced (Angioni et al., 2011). It has been reported that cold storage (10°C) for fifteen days may increase anthocyanins in berries, but the same results have not been recorded for fully ripe berries, while over-ripe storage of fruit under the same conditions causes a decrease in anthocyanin concentration (Mulas et al., 2013). Another tool used to maintain the quality of myrtle berry before processing is frozen storage at 2°C. However, some experimental evidence has shown that this technology also adversely affects fruit composition and consequently the quality of liqueurs (Tuberoso et al., 2008; Angioni and Schirra, 2011). Oxygen-enriched atmospheres have been used successfully to maintain the quality and prolong the life of a wide range of fruits and vegetables (Kader and Ben-Yehoshua, 2000; Zhenget et al., 2003; Zheng et al., 2007; Zhenget et al., 2008; Maghoumi et al., 2013). To obtain the highest quality pure essential oil by steam distillation, the following items must be followed; collection of young leaves or flower twigs before the afternoon, distillation should be carried out immediately, containers should be made of stainless steel and it takes three hours to distill after boiling.

Part V: Utilization

Myrtus berries are edible in some countries such as Sardinia. It is widely found in some other countries and is used in their traditional medicine as a Mediterranean region, especially in Italy and Greece. It is used for preparation of famous liqueur called “Mirto". The dried and fresh leaves are used in Mediterranean food dishes and in its wood as a flavoring material as in Italian food. It is also good as firewood. In traditional medicine, the leaves and berries are used as astringents, antioxidants, expectorants, antiseptics. Its essential oil, 0.3-0.6%, contains cineole, mirtenil acetate, myrtenol, α-Pinene and geraniol. The essential oil of the leaves is used for the preparation of aromatic sauces, food industries, beverages, cosmetics.

3.3.12 Pimpinella anisum (anise)

Part I: General aspects

Figure 3.32. General morphology of anise

Classification:

Scientific name: *Pimpinella anisum* L.

Common name: anise, sweet cumin

Family: Apiaceae

Origin and distribution:

Generally, anise (see also Figure 3.32) is considered to have originated in the Eastern Mediterranean area. It was transported to India via Persia. Anise fruits, which are known in the spice trade as "seeds”, found their way to China (Canton) in 1200 AD through a shipment from Java. For the time being, a anise has a wide production as it is cultivated in southern Europe as Italy and Spain, Russia, Turkey, India, Bulgaria, China, Iran, North Africa etc., while it does not produce a good growth characters in lowland of tropical areas, but sometimes anise grown in South east region of Asia.

Production levels:

40-50 tonnes of anise essential oil is produced annually. The United States is considered the largest importer for anise essential oil, as is France, while Poland, Russia, and Spain are considered the largest oil producers (Basher, 1997; Yalcin, 1988; Arctander, 1960).

Plant description:

The height of the anise ranged from 30 to 70 cm, the leaves are triangular fins while small white flowers are distributed from seven to fifteen rays in collective umbels. Anise leaves are simple at base with 1.3 to 5.1 cm in long, which are shallowly lobed. In contrast, leaves at the stem top are feathery pinnate with division into numerous leaves (Chevallier, 1996).

Anise sweaty smell fruit is laterally ovoid or pyriform reach length 3-5 mm with 2-3 mm in width and has two carpals. The color of the fruit appears from greyish-green to greyish-brown. Seeds are greyish-brown, curved, and small and extended to 0.5 mm in length. The pericarp is broadly ovoid, five ridged with short hairs and various vittae (Ross 2001). The essential oil is located in the schizogenic oil ducts of anise fruits, and shoots (Figueiredo et al., 2008).

Climatic requirements:

Anise plant cultivation needs a warm, sunny and dry autumn, ideal to meet economical yield and best essential oil quality (Ebert, 1982; Poss, 1991). Anise can be grown in temperate and subtropical climates but does not grow well under tropical lowland conditions. It requires a frost-free growing season of about 120 days. It grows under conditions ranging from 1,000-2,000 mm average annual rainfall and mean annual temperatures from 6-12 to 18-24°C. Moisture requirements are highest in the period from stem emergence to flowering. Temperature and rainfall should be rather uniform because anise is unfavorably affected by sudden changes in both.

Soil requirement:

The anise plant grows well in light to medium weight loose soil. Various types of soil from sand to clay can be used to grow anise with varying pH range (5-8), but thrives on well-drained, medium to heavy clays with sufficient water holding capacity. Sandy soils and heavy clay soils are unsuitable.

Part II: Cultivation practices

Propagation:

The traditional production of anise by sexual propagation (seeds) does not guarantee uniformity of plant progeny is a cross-pollinating species and is thus genetically heterogeneous. Plant tissue culture technology offers an alternative method for the propagation of medicinal plants such as anise (Amer and Omar, 2019)**.**

Soil Preparation:

Prior to sowing, the soil is often ploughed and harrowed to obtain a fine seedbed.

Planting:

Fifteen to twenty kg/ha of seeds are required to grow anise with 20 to 30 cm between rows has proven successful in Europe. Because anise seeds germinate in the dark, the fruit is sown 1.0 to 1.5 cm in the ground, lightly pressed with a roller and then covered with soil. After 2 to 3 weeks, depending on the weather, the anise germinates (Habib, 2012). Seed prices range from 6-15 kg/ha. The crop is sown in October-November in northern India and in March-April in Europe.

In terms of in vitro propagation, multiple shoot formation has been achieved from callus cultures derived from shoot apices, root and stem explants and seeds. Somatic embryogenesis has been observed in callus cultures derived from shoot tops, root explants and seeds. Plants have also regenerated directly from shoots.

Fertilization:

Awad et al. (2005) demonstrated the effects of organic and nitrogen fertilizers on on the quality and quantity of anise plants. The results showed that inoculation with N_2 fixing bacteria (Azotobacter chroococcum and Azospirillum Lipoferum) with half doses of chemical nitrogen fertilizers affected the production of anise plants both in quality and quantity. Ammonium nitrate and urea plus mixed cultures of N_2 fixing bacteria (*Azotobacter chroococcum* and *Azospirillum Lipoferum*) gave highest values of shoot dry weight, fruit and essential oil yield. In addition, bio fertilizer and ammonium nitrate significantly enhanced shoot dry weight, fruit yield and essential oil compared to urea. According to Khalid, (2015) fertilization with N_2 (200 kg N ha^{-1}), P_3 (75 kg P_2O_5 ha^{-1}) x micronutrients resulted the maximum mean values of essential oil content (3.3%) and yields (0.3 ml $plant^{-1}$). The oil major compounds are trans-anethole (65.6%), estragole (5.6%), fenchone (5.6%) and camphor (3.1%)] resulted from the N3 P3 x micronutrients treatment (Khalid, 2015).

Adequate nutrient supply is essential. The crop intake required to produce 100 kg of fruit is 3.5 kg N, 1.5 kg P_2O_5 and 4 kg K_2O. Most of it is absorbed during the period from the appearance of the stems until flowering. Anise can be staked as the plants mature, to support the tops heavy with fruit.

Irrigation:

Irrigation is considered as an important factor influencing plant growth and phytochemical production (Randhawa et al., 1992). Hornok (1992) concluded that the application of insufficient water through seed germination and the period from stem elongation to flowering can reduce anise yield by 150 to 200 kg ha^{-1}. It has been documented that adjusting irrigation can increase anise grain yield without any effect on essential oil content (Abdel-Kawy et al., 1981).

Harvesting:

The harvesting of anise is difficult because the umbels ripen progressively, and fruits ripen unevenly on each umbel (Stephens, 1997). For using fresh leaves of anise snipping can be used and they can be dried in a dark, cool, dry and well-ventilated place whereas a seed requires more time (100 frost days) to be suitable for harvesting. Harvesting should be completed before the first frost in the fall.

Disease control:

In well cultivated and healthy anise stocks, disease and pests only seldom appear (Heeger 1956). It has been documented that the Puccinia pimpinellae Mart can cause rust disease for anise which is considered as destructive and common anise disease in Egypt (Ghoneem et al., 2009)

Part III: Post-harvest handling

The extraction of milled Pimpinella anisum (Yansoon) seeds is performed using two different extraction methods: organic extraction with methanol (polar), hexane (nonpolar) and hydro-distillation method for the separation of the essential oil from anise seeds (Mohammad and Abu-Rumma, 2018). Essential oil components and content is basically considered as quality character for anise.

It is required to evaluate all environmental factors that affect the quality characteristics of anise (Omidbaigi, 2000) and the essential oil content. Environmental factors as well as genetic characters are the most influencing factors on yield and essential oil (Orav et al., 2008; Zheljazkov et al., 2008), anise contains about 1.5-5.0 essential oil with phenylpropanoids compounds as majors (90%) as trans-anethole, γ-himachalene, methyl chavicol (estragol), anisaldehyde, β-himachalene and α-zingiberene (Omidbaigi et al., 2003; Tabanca et al., 2005).

The moisture content of the fruits should be reduced to 10-12% before they are threshed, cleaned and stored in polyethylene-lined jute bags in a cool, dry place. Storage is difficult, because the essential-oil content decreases rapidly. It is therefore recommended to store fruits in airtight containers in a cool and dark place. To extract anise oil, the fruit must first be crushed and distilled immediately to reduce oil loss due to evaporation.

Part IV: Utilization

The anise tea is used for children's flatulence, upper respiratory tract problems, and bronchial asthmatic attacks (Buchman, 1987). The tisane tea is also used as an expectorant (British herbal manufacturing Association, 1996), as a cough suppressant (Fluck, 1988).

4-methoxyphenyl-1-propane (trans-anethole), the main component of anise oil, is a precursor for production of 2, 5-dimethoxybenzaldehyde used in psychedelic drugs synthesis as DOB (2, 5 dimethoxy-4- bromo amphetamine) (Waumans et al., 2006). Anise is useful in destroying body lice (Spoerke, 1980), head lice, and itching insects (Buchman, 1987) and the oil can be used by itself (Hoffman, 1991), which makes it helpful for pediculosis, the skin conditions caused by lice (Newall et al., 1996). It can also be used for scabies (Ody, 1996), where it may be applied externally in an ointment base (Hoffman, 1991).

3.3.13 X Sorbaronia mitschurinii (black chokeberry)

Part I: General aspects

Classification:

Scientific name: X *Sorbaronia mitschurinii*

Common name: black chokeberry

Family: Rosaceae

Figure 3.33 General morphology of the black chokeberry flowers and fruits

Origin and distribution:

Natural intergeneric hybrids between Sorbus and different species of Aronia occur in eastern North America (Postman, 2011; Leonardet et al., 2013) (see also Figure 3.33). In Europe a species recognized as *Aronia mitschurinii* A.K.Skvortsov & Maitul is known in North America as cultivars of Aronia melano carpa including 'Viking', 'Nero', and 'Aron '(Leonardet et al., 2013). Historically, it is cultivated in the former Soviet Union (Agroforestry, 2020 electronic site).

The native species in Eastern North America is Aroniamelanocarpa and is a diploid (2x=34), breeders efforts in Germany and Russia have produced cultivars that are tetraploid (2x=68) and have sometimes been designated as A. mitschurini (X Sorba roniamitschurinii (Skvortsov & Maitul) Sennikov).

Production levels:

The black chokeberry yield is about 38 pound of fruits/plant (Knudson, 2005), while Kask (1987) found that the average yield of black chokeberry plant when pruning all canes back to 1 m every four to five years after the plants became eight to ten years old was 5.3 - 7.7 t/ha in the Soviet Union. The Aronia plant is not widely spread in Africa. Also, it is new to South Africa (Berries for Africa, 2020 electronic site).

Description of the plant:

The plant reaches 0.5-3 m tall. It is a deciduous shrub with shiny green leaves that turn bright reds and oranges in the fall. It blooms in May and gives white flowering clusters, and dark blue fruit that can be up to 1 cm in diameter (Strik et al., 2003). X *Sorbaronia mitschurinii* (Skvortsov & Maitul.) Sennikov plants are self-fertile, leaves are broader, and the fruits are larger than that of the wild Aronia melanocarpa. The flowers are white, purple or red colored carried on terminal clusters (Compound corymbs inflorescence).

Climatic requirements:

Strik et al. (2003) mentioned that Aronia plants is cold hardy to about -29°C and is not sensitive to spring frost due to the late flowering time. Also, Skvortsov and Maitulina (1982) showed that the native North American Aronia plants are moderately hardy (Zone 4), while the European Aronia cultivated plants are extremely hardy it can be planted at Zone 2. Concerning the chilling requirements, Aronia plants needs approximately 800 chill hours (accumulated between 0°C and 7°C) in winter for optimum fruit production.

Part II: Cultivation practices

Propagation:

Black chokeberry plants are propagated naturally by seeds and suckers.

Soil preparation:

They are well suited to a wide range of soil types. Aronia shrubs can grow well in very wet winter soils that may be caused by slow drainage as well as dry summer soils. The optimum pH level to grow aronia plants is slightly acidic (6.0 to 6.5), but aronia will tolerate a wider pH range (5.0 to 8.5) (Berries for Africa, 2020 electronic site).

Soil tillage improves the soil conditions. It is important to maintain relatively smooth, level ground for orchard work and harvesting. Organic matter can be added to the soil in order to improve the soil properties TO enhance the growth of the plants.

Planting:

Planting density for machine harvest is usually about 1,600 to 1,900 plants per hectare. For mechanical harvest, plants are spaced 1.0 to 1.8 m apart in rows that are 2.8 to 4.0 m apart. The plant density can be increased to around 3,500 plants per ha on farms where the fruit is harvested by hand with plants planted 1.0 m apart within the rows and 2.8 m spacing between rows (Berries for Africa, 2020 electronic site). Generally, Aronia has been planted at a spacing of 2 x 4 m (Strik et al., 2003).

Fertilization:

At poor sandy soil, the recommended fertilization rates are 50 kg/ha of nitrogen, 35kg/ha of phosphorus and 45 kg/ha of potassium (Berries for Africa, 2020 electronic site).

Irrigation:

Aronia plants are not drought tolerant but they can usually withstand dry summer soils once established. The annual demand for water is 32 or more inches (more than 800 mm) of rains spread evenly throughout the year (Stewart, 2012).

Disease control:

Aronia plant is a hardy plant, tolerant to many diseases and pest infections. Quince or apple Rust caused by Gymno sporangium spp can infect the flowers and fruits of the plants, however the infections are minimal and can be removed from the plants by hand. In addition, when powdery mildew infects the plant, forming of white or gray spots on the leaves will occur and then cause the defoliation of these leaves. It can be controlled by spraying various fungicides and organic controls like potassium bicarbonate. Besides, pests attack the plants to feed on its parts. The aphids attack the leaves plant while cherry fruit worms (*Grapholitapackardi*) attack the fruits, meanwhile Japanese beetles (*Popillia japonica*) attack both leaves and fruits of the plant (UMD, electronic site).

Other cultivation practices:

Pruning is required to keep plants at a manageable size, to maintain yields and to facilitate mechanical harvest. As canes age, they become less productive. For maximum yield and plant longevity, annual removal of canes or stems greater than one inch in diameter is required.

Harvesting:

The berries can be harvested by hand or with a mechanical harvester.

Part III: Postharvest handling

The fruits are collected at plastic containers. Then are sorted and packed in plastic punnets. The fruits stored at 4°C and that is the temperature that made no changes at anthocyanin content (Jurikova et al., 2017)

Part IV: Utilization

The fruits used for juice, wine and jams. More recently cultivated commercially with the fruit used as flavouring, food colourant, and component of fruit juice mixes.

The fruit is valued as a great source of antioxidants, especially polyphenols, such as phenolic acids (neochlorogenic and chlorogenic acids) and flavonoids (anthocyanins, proanthocyanidins, flavanols), particularly cyanidin-3-galactoside and cyanidin-3-arabinoside (Jurikova et al., 2017). They contain vitamin also C and E, mineral elements (potassium, calcium and magnesium), carotenoids and pectins.

The Aronia melanocarpa berries have medicinal and therapeutic benefits which are gastroprotective, hepatoprotective, antiproliferative or anti-inflammatory activities due to its strong antioxidant activity and content (Jurikova et al., 2017).

3.3.14 Ribes nigrum (black currant)

Part I: General aspects

Classification:

Scientific name: *Ribes nigrum*

Common name: blackcurrant or black currant

Family: Grossulariaceae

Figure 3.34 General morphology of black currant

Origin and distribution:

Black currant (see also Figure 3.34) is considered as a native plant in the region of Northern and Central Europe as well as North Asia. Poland and Germany are considered the most important producers as they produce about 50% of the world blackcurrant production. Germany, the United Kingdom, Norway and Hungary were also considered major producers for this species in the late 1980ies (FAO 1989, 1990).

Production levels:

Commercially, black currant (soft fruit cultivation) has an annual production of 185,000 tonnes worldwide and 160,000 tons in Europe (Hedley et al., 2010). It could be concluded that Germany, Poland and the United Kingdom contribute about 80% of total production. Total world production of blackcurrant averaged about 205,150 tons in 2006. Subsequently, production figures ranged from 166,320 tonnes (2007) to 185,535 tonnes (2008) and then to 136,446 tonnes (2009). Globally, Poland is by far the largest producer of black currants, with the United Kingdom in second place. Among non-European countries, New Zealand is the main producer followed by Canada and the United States. In Sweden, commercial production covers about 350-400 hectares and there is still great potential for crop growth due to favorable climatic and soil conditions, preferably in the south. Production figures for the Russian federation and China are not available, although blackcurrants are an important soft fruit crop of growing economic importance in these areas.

Description of the plant:

The medium size shrub, black currant, is a woody shrub which is growing up to 1.5 m. Its alternate leaves are simple and broad 3-5 cm with 5 palmate lobes accompanied with serrated margin. Flowers are presented as racemes up to 8 cm contain 10-20 flowers each is 8 mm in diameter. This hairy flowers contain glands have yellow color. The inconspicuous petals are shorter than the flowers. The style and stigma as well as the two fused carpels are surrounded by five stamens. Flowers are pollinated by insects and winds. Strigs of green fruits will ripen to be edible with dark purple color and glossy skin at the mid of summer season containing many seeds. Plant parts seem to have aromatic smell.

5. Climatic requirements:

Frost can damage both unopened and open flowers when temperatures drop below −1.9° C. Black currants are known for their winter hardiness and adaptability to temperate growing conditions. The crop has the best performance in climates with cold winters and mid-summer. The high temperatures in the middle of summer, especially the intense sunlight, cause a greater risk of damage to the foliage. During dormancy, cooling is insufficient which can have urgent effects on the duration and timing of flowering, fruit quality at harvest and bud break. Drought in summer and frost in late spring are known to cause problems in the cultivation of black currant. It is reported for black currants that hot conditions increase the accumulation of solids and reduce the acidity of the fruit with less effect on sugar.

Soil requirements:

It is successfully grown in wet fertile soil and not in the waterlogged one, as it has water intolerance. It is cultivated domestically and commercially, but it also grows well in heavy loam and sandy soils as well as in forest soil. The ideal pH for growth is close to 6, while in case of acidic soils farmers can add lime to adjust pH, as it prefers slightly acidic soils. However, it can grow in all medium, neutral, basic and acidic with light or in shade.

Part II: Cultivation practices

Propagation:

Black currants are typically propagated with 15-25 cm hardwood cuttings taken from dormant plants in late autumn to late winter.

Planting:

When planting, it is best to soak the roots for 1-2 hours before planting and prune the damaged and inappropriate roots. When the plants are placed in the ground, burying 1-3 buds will help to encourage root growth and revitalize the steams. Pruning 6-10 inches after spring planting can also help encourage the growth of new stems. Potted plants can be applied all year.

One- and two-year old shrubs can be used. The distances should be 1.5-1.8 m in a row and 1.2 m between plants. Usually, the young bushes are grown deeper than the original ones to enhance the growth at their base.

Fertilization:

The blackcurrant requires a number of essential nutrients to be able to thrive; nitrogen provides strong plant growth and stimulates the production of flower sprigs; phosphorus helps in the growth, the setting of fruit and crop yield; potassium promotes growth of individual shoots and increases the weight of individual fruits; magnesium is a constituent of chlorophyll and helps increase yields through interaction with potassium; calcium is required for cell division and enlargement and is particularly important for young plants and buds.

Well-rotted manure and poultry manure as well as compost of vegetable waste materials could be added annually in the spring, as well as nitrogen, phosphorus and potash fertilizers. Granular balanced (10:10:10) artificial fertilizers can be used at 100 to 240 g per plant.

Irrigation:

Studies in Ribes nigrum varieties to evaluate water tolerance and water recovery through flower initiation have shown that the Titania variety can tolerate drought stress more than the Ben Hope variety. Insufficient irrigation in the long-term examination reduced the number / node of flowers in the "Ben Hope" variety, while the increase in temperature at the beginning of flowering with the Titania variety showed urgency for flower formation. Therefore, reproduction can be used as a tool to adapt the variety to tolerate drought and temperature changes to cope with future climate change (rekereković et al., 2014).

Adequate water is needed for black currants to flower and yield properly, at about 1 inch per week from flowering to harvest and periodically after harvest during periods of drought (Bratsch and Williams 2009). Irrigation is more important from flowering until harvest, particularly during dry periods when rainfall is not adequate (Ostermann and Hansen 1988). However, maintaining adequate moisture in the fall during floral and leaf initiation is also important for keeping an optimal number of stings and flowers per node (Cerekovik et al., 2014).

Soil moisture should be maintained at 15-20% on a stony silt loam, particularly in the establishment years and early years. Fewer than 15% soil moisture, berry yield begins to drop while maintaining soil moisture above 20% can be difficult and expensive. Irrigation does little to reduce soluble solids and only effects berry weight in the first few years after planting

Disease control:

Reversion is a serious disease transmitted by the the blackcurrant gall mite Ccidophyopsis ribis. It is widespread in Europe and shows a significant reduction in yield. Signs of infection appear as swollen buds in winter and modified leaf shapes in summer. Infected bushes have to be removed. Powdery mildew and mildew can infect the tips and leaves of shoots and can cause the fruit to rot in wet season. Another disease can infect black currant called Currant and gooseberry leaf spot caused by Drepanopeziza ribis, but now some varieties are resistant to this infection.

Other cultivation practices:

Organic mulch can depress the growth of weeds such as sawdust, mushroom compost or straw, organic mulch cover or landscape fabric with heavy plastic topped.

Blackcurrant fruit is born one-year-old shoots. Sever pruning is recommended for blackcurrant by cutting shoots to keep only two buds above the ground level in order to give plant chance for proper establishing, before consuming its energy in flower production. Pruning, targeted removal of weak shoots can be weighed during fruiting. The remained braches should be thinned to remove unproductive parts and encourage new shoots. All these items can help in avoiding overcrowding each year and help in production of more healthy plants and fruits as well as facilitate mechanical harvesting.

Harvesting:

In commercial route, the harvest is mechanically applied through the continuous movement down the rows, complicating a series of bushes, shaking the branches, and stripping off the fruit. The collected berries are mainly placed in half-tonne bins to reduce the standing time. The new machines can select about 50 tonnes / day from a single operator and two tractor drivers, while the garden currant can be harvested, when the berries are ripe and dry.

Part III: Post-harvest handling

The bins should be stored in a cool place. Some fruits are still picked by hand for use in the fresh fruit market.

Part IV: Utilization

Blackcurrant fruits are a good source of minerals and vitamins, especially vitamin C. Its juice has many actions as diaphoretic, diuretic, increases infection resistance of body, treating cold and flu, calm indigestion, diarrhea, enhancing fluid elimination that reduce blood volume and lowering blood pressure.

The infusion is used for treating rheumatic pain, dropsy, whooping cough, abscesses, used externally on slow-healing cuts, gargle for treating sore throats and mouth ulcers. Infusion of fresh or dry leaves collected at growing season is used to increase cortisol secretion to stimulate sympathetic nervous system, which is useful for treating stress conditions. Young roots infusion is used in treating eruptive fevers, while bark decoction is used for treating calculus and dropsy. Seeds is considered γ-linolenic acid source, which assist hormone like substances production, blocking of this process caused many disorders in metabolism, nervous system and affect the uterine muscles. This oil is used in cosmetics and skin preparations and mostly combined with vitamin E to prevent oxidation. On the other hand, leaves are used as a source of yellow dye. A blue or violet dye is obtained from the fruit. The leaves are used for vegetable preservation.

3.3.15 Ribes rubrum (red currant)

Part I: General aspects

Classification:

Scientific name: *Ribes rubrum*
Common name: redcurrant, or red currant
Family: Gooseberry

Figure 3.35. General morphology of red currant

Origin and distribution:
Red currant (see also Figure 3.35) is native across Europe. The species can be cultivated but also thrives into the wild in many regions.

Production levels:
The fruit production of *Ribes* crops (black- and red currants and gooseberries) is mainly destined for processing and freezing industries with less fruit going to the fresh market. Blackcurrant has been cultivated in Poland, United Kingdom, Denmark, France, Germany, and New Zealand with a fully mechanized fruit harvest and maintenance of plantations. Redcurrant production often supplements the blackcurrant cultivation. The main producers are Poland, the Netherlands, Belgium, Germany, France, Czech Republic and Slovakia, with very small quantities in Chile. Production of gooseberry is smaller than black- and red currants. The prices of *Ribes* fruit and the crops profitability for growers in different countries depend frequently on the weather conditions and the resulting yield. The fruit

production and selling of black- red currants and gooseberries in some EU countries and New Zealand is based on the written contract agreements between processing industries and growers. between processing industries an growers.

Description of the plant:

Ribes rubrum, deciduous shrub, is growing up to 1-1.5 m height and occasionally reach 2 m. Leaves are five-lobed distributed on stems spirally. Flowers appeared foggy yellow-green, in pendulous 4-8 cm racemes. Flowers matured to be bright red translucent edible berries (8–12 mm diameter). Berries reach 3–10 on each raceme. A bush may produce 3–4 kg berries from mid to late summer.

Climatic requirements:

Currants thrive in cool, well-drained fertile soil, in full sun or in partial shade. In warm regions, the bushes prefer heavy soil and should be planted in partial shade or on a north-facing slope. Organic mulch can be used to protect the roots and keep the soil cool and moist.

Soil requirements:

Suitable for sandy, loamy and clay soils. It is plausible for plant to grow in well-drained soil. Suitable pH: neutral, basic and acidic soils with moist. Semi-shade or no shade areas are suitable for growing.

Part II: Cultivation practices

Propagation:

Propagate by hardwood cuttings in autumn

Soil preparation:

Site preparation should begin with the eradication of perennial weeds in the planting area. Translocated herbicides can be used for removal of perennial weeds in targeted area for planting. This application should be carried out from mid-summer to late summer. Evaluation of the soil acidity is necessary to calculate the suitable amounts of fertilizers, phosphorus and potassium, which will be required.

In case of neutral soil, phosphorus at 23-34 kg/acre and potassium at 68-90 kg/acre should be added whereas in soil with acidic medium (pH below 5.5) lime should be added to increase pH up to 6-6.3. In order to avoid loss of nutrients, nitrogen fertilizer should be added at 11-16 kg/acre in spring. Because of the sensitivity of currant to chloride, potash must be avoided and compensated with another potassium form. Fertility management after planting is specified according to crop age, soil type, and use of manures.

Planting:

Currently red currant (*Ribes rubrum* L.) is propagated by cuttings because there is no suitable method available for micro-propagation. Cutting propagation consumes more time than other methods making it difficult for the new cultivars of *Ribes*. Developing new micro-propagation technique for red-currant may improve the quality of plant and can introduce a tool for cryopreservation of old cultivars. For the propagation, bushes of two- to three-year-old are needed with a well-balanced head of three to five main branches and a clear stem of 10-15 cm. The bushes must be spaced 5 feet apart. In order to grow currants in tree form, all but the top three buds from the cutting should be removed so sprouts will not grow from below the ground. Cuttings must be set in the ground in the fall or early spring.

The yield could be increased by pruning annually to keep plants in healthy conditions. As pruning enhances fruiting, fruits will mostly be borne on 2-3 years old wood. The renewable pruning method is used for maintenance of 2 or 3 each of 1-3 years old stems. Two or three stems should only be kept at the plant ground level at the first and second winter. At the fourth winter, the branches at the base that are more than three years old should be removed. Plants also can be grown as single stem in cordons, by 45 cm apart or grown against wall. For developing cordon, single stems should be shortening each winter to be around 15 cm.

Fertilization:

Currants require high amounts of nitrogen and potassium. In order to keep plants from potassium deficiency, half ounce real potassium/ yard^2 should be added. In contrast, currants are highly sensitive to chloride as it causes toxicity to it therefore it is preferable to add potassium in any form except chloride. Accordingly, potassium sulfate is used in application of balanced fertilizers (N:P:K) at 10:10:10 magnesium or nitrate could also be added. At the second year, 100-140 g of balanced fertilizer (10:10:10) should added per plant and it can be substituted with another fertilizer that has the equivalent rate with nitrogen application at 2 kg/acre. Application should be spread in drip line under branches. The rate of fertilization should be increased slightly at the third year of planting. In mature plants (at the fourth year) 170-220 g of balanced fertilizer should be applied in each plant with real nitrogen of 10-20 kg/acre.

The requirements of plant are assessed according to plant growth. Compost or manure is considered best source for nutrients if they are available for ribes, which respond well to slow release from organic nitrogen sources.

Irrigation:
One inch of water/week is required for currants from blooing to ending of harvest in order to keep the highest growth, yield and size of berries. If there is mulch, the rainfall water is enough for the plant but in shortage of rainfall irrigation to reach the requirements is recommended. Dripping and trickle irrigation are accepted to avoid diseases. Regarding dry times after harvest, periodical water is advised until September. After each drying time plants need 6-8 inches of water. Irrigation through blooms can help in avoiding frost injury. Little amount of water is acceptable for plants when temperature is below zero. Trickle systems are not advisable for protection from frost.

Disease control:
Fungal leaf spots and coral spot can occur.

Other cultivation practices:
Main pruning is carried out in dormant season, along with summer pruning of vigorous laterals**.** Level, shallow cultivation should be applied to avoid harming roots. It is advisable to add organic mulch straw, compost or other material after planting around the plant base. Mulching helps to conserve soil moisture, cools the soil, and suppresses weeds. The mulch should be two to four inches deep, with additional annual applications made to maintain this depth as decomposition occurs. Nitrogen deficiency occurred as yellowish color of older leaves while rodent can infest the mulched regions so it could be controlled.

Harvesting
Currant is considered very productive plant at the maturity stage with 5-8 pounds/plant (ca. 2.3-3.6 kg). The red currant reaches it's economic capacity at the third and fourth planting date while black currant reach the same stage at fourth to fifth year. Life of currant is mostly eight to fifteen years depending on plant variety. The fruit ripen over an extended period can remain on the plant in cool weather that allow harvesting schedule flexibility.

Fruit are harvested in mid-summer. To reach ripen for currants, it needs two weeks or more than that depending on weather conditions. Fully ripe berries can be remained on bush for a week with keeping the same level of maturity, but some varieties can loss berries acidity by the same time. Berries can be harvested weekly that allow slower maturing and increase number of harvest to 2-3 pickings. The red currant is tuned into red color before fully maturing of berries so they should remain in the plant additional time to get their flavor and sweet taste by time. Usually harvest time is recorded by the sign of bird predation. Harvesting needs gloves. It is preferable to spread out canvas under the bush, and fruit knocked off on to it. When berries reach full size they can be harvested for jam and pies while full colored ripeness berries are suitable for juice.

Part III: Post-harvest handling

As currant fruit are soft, it should be stored in quart containers and not be placed in depth. Both types of fruit can be frozen and kept for later use.

Part IV: Utilization

When picked just after they turn red, red currants are used for jellies, sauces, pies and wine. Fruits can be eaten when berries turned to red in red varieties or translucent for white varieties. Currants are used commonly in northern European countries while they were less spread in United States until recently as they were known as s carrier of white pine blister rust. The ban was lifted in 1966, and currants are now enjoying some renewed interest in USA.

Recently red currant, used in vitro studies, is reported as a good dietary source with potential anti-diabetes and anti-hypertension functionality (da Silva Pinto et al., 2010).

3.3.16 Ribes sanguineum (flowering currant)

Part I: general aspects

Figure 3.36 General morphology of flowering currant

Classification:
Scientific name: *Ribes sanguineum*
Common name: flowering currant, redflower currant, or red-flowering currant
Family : Grossulariaceae

Origin and distribution:
Flowering currant (see also Figure 3.36) is native to western United States and Canada (British Columbia, Washington, Idaho, Oregon, California).

Description of the plant:

This shrub may grow up to 2 m height. Its' bark appears brownish grey with pale brown lenticels. Its' leaves are broad and have 2-7 cm in long and lobed as five lobes. In spring the young plants show strong resinous scent. Leaves and flowers are emerged at the same time in early spring. Flowers are appeared on dangling racemes, 3-7 cm long for 5-30 flowers whereas each flower's diameter is 5-10 mm with pink or red petals. Fruits are dark purple oval berry (1 cm in long), edible with savorless taste.

Climatic requirements:

Flowering Currants can be grown in full sun, but they prefer partial shade.

Soil requirements:

The plant can grow in varied soil types including loamy, clay, heavy clay and sandy soils with well drained conditions. It can be grown also in varied pH levels as neutral, basic and acidic soils. It grows well in light or semi shade areas with moist soil. It can tolerate salinity exposure.

Part II: Cultivation practices

Propagation and planting:
Ribes plants are cultivated in fall by sowing directly in field or in cold frame. Seeds should be cleaned well before planting or storage. Propagation of flowering currants is done by cuttings in early summer. Another method of propagation is by tip or ground layering. This is done by pinning the tip of a branch to the ground where it will root. Once rooted the new branch from the parent plant can be severed and transplanted it to a new one.

Irrigation

This shrub requires little amount of water during the first week of planting and through fruiting time. This water amount may be increased when they are grown in pots or in drought times as its root must be well covered with mulch. It is required to allow the soil to dry in between irrigations during first and second season and water could not be provided from mid to late summer, at the beginning of leaves fallen.

Disease control:

May be affected by a leaf spot, powdery mildews, honey fungus and coral spot.

Other cultivation practices

Pruning is applied only once every two years, shortening each branch by one-third of its length. This must be done after flowering, in May-June.

Harvesting

Fruits are harvested when are ripe.

Part III: Post-harvest handling

Fruit leather process is used to make and preserve red-flowering currant fruit by mashing, spreading, and drying into cakes.

Part IV: Utilization

The berries of the Red-flowering Currant are a native food for both humans and wildlife. They are closely related to the European Red Currant, commonly cultivated for their edible berries in Europe. Native peoples of the region use/used the berries both fresh and dried.

The location of growing is an important factor that affects berries characters as taste (bland-sweet) and texture (mealy to juicy). Full sun exposure, sufficient water application and rich soil increase natural sweet taste. Drying into currant raisins increases its natural flavor to be suitable for making jam, pies and syrup.

3.3.17 Zea mays L. (maize)

Part I: General aspects

Figure 3.37. General morphology of maize

Classification:

Species: *Zea mays* L. – corn, maize

Family: Poaceae

Origin and distribution:

Maize (see also Figure 3.37) is originated from Mexico and Central America; also, it is widely cultivated at temperate regions all over the world. (Nafziger, 2010; Hossain et al., 2016).

Production levels:

The maize world's productivity is 1.147 billion tonnes. USA is the largest producer of maize with 392.45 million tonnes, followed by China with 257.17 million tonnes, followed by Brazil with 82.28 million tonnes. The Americas produce about 50.4 % while Asia produce about 31.5 %, followed by Europe with 11.2% then Africa with 6.9 % of the world's productivity (FAOSTAT, 2018).

Description of the plant:

Zea mays L. is an annual plant which considered to be the most important cereal grains grown worldwide. It is consumed as grains by humans or as animal feed (cattle). According to the amount of starch in the grains, various subspecies can be classified under *zea mays* L. such as *Zea mays* var. *amylacea* (flour corn), *Zea mays* var. *everta (*popcorn) and *Zea mays* var. *saccharata* (sweet corn).

The permanent roots of the plant are adventitious and prop roots, the adventitious roots formed from the nodes below soil surface at the crown. The plant reaches 3 m height, the stem is cylindrical, solid and is divided into nodes and internodes. The leaves are arranged spirally on the stem. The plant carries 8 to 20 leaf, each of them grows from each node 9 cm in width and 120 cm in length. The maize leaf consists of a sheath, ligules, auricles and a blade. The leaf blade is long and narrows (Du Plessis, 2003). On the same plant, male and female flowers are formed on separate inflorescences. Halfway up the stem, ears (female inflorescences) are formed between the stem and leaf sheath, it is tightly enveloped by several layers of ear leaves commonly called husks, the elongated stigmas are called silks which emerge from the whorl of husk leaves at the end of the ear. While the male inflorescence is formed at the apex of the stem which called tassel (Du Plessis, 2003).

Climatic requirements:

The maize plant is a warm weather crop that does not grow at areas where the mean daily temperature is less than 19 ºC or where the mean of the summer months is less than 23 ºC and the optimum temperature range for germination is between 20 and 30°C. In addition, high temperature about 38 ºC affects the viability of the pollen grains thus affecting the yield, and the 32°C is the critical temperature that affects the yield. Since maize is a warm weather crop a frost-free period of 120 to 140 days is required to prevent damage (Du Plessis, 2003).

Soil requirements:

Maize can grow well in most soils as the soil depth is 1 m and more and have a good water holding capacity. Maize is susceptible to drought and waterlogging. It needs well-drained, fertile soil (Nafziger, 2010).

Part II: Cultivation practices

Propagation:

Maize is propagated by sowing seeds directly in the field. It can be cultivated by mechanization (Planters) or manually by broadcasting the seeds.

Soil preparation:

Site selection is very important; it is better to cultivate it at well drained soils. Soil tillage improves the soil conditions.

Planting:

According to the environmental yield potential and hybrid, the number of maize plants in the field varies between 36,000 to 60,000 plants/ha (Nafziger, 2010), thus the width of the row (0.9, 1.5 or 2.1 m) and the space between the plants within the row, differ according to the planting density. The sowing depth of the seeds varies from 5 to 10 cm, depending on the soil type and planting date; the planting depth of the seeds is shallow in heavy soil compared with the sandy soils (Du Plessis, 2003).

Fertilization:

In order to calculate the nutrient quantities that the plants need, soil and leaf analysis are performed. Organic fertilization is very important for maize production,like manure that is an excellent source of nutrients and has many other benefits for soils. Bar-Yosef (1992) mentioned the optimum fertilization rates for maize production by fertigation that was 240 kg N, 91.6 kg P_2O_5 and 385.4 kg K_2O. According to the size of the resulting fresh weight and grain yield, it is recommended to fertilize maize with 120 to 160 kg of nitrogen, 40-60 kg of phosphorus, 130-170 kg of potassium, 30-45 kg of calcium, 25-35 kg of magnesium and significant amounts of essential micronutrients per hectare (Kandil et al., 2020; FOSFAN, 2020).

Irrigation:

Concerning the water requirements for maize, 500-800 mm / season is needed. Drought during the blooming (silking and tasseling) can cause serious yield losses (Critchley et al., 1991). Maize is usually produced under full irrigation in order to obtain the highest yields.

Disease control:

Maize is infected by various bacterial and fungus pathogens. Anthracnose is a fungal disease that is caused by the infection with *Colletotrichum graminicola.* Its symptom is the formation of small oval or elongated water-soaked spots on leaves, severe infection leading the plant to die. It can be controlled by cultivating hybrids resistant to anthracnose, rotating crops and plowing crop debris into soil. Also, maize is infected by *Puccinia sorghi* fungus which causes common rust disease. The symptom of common rust is the formation of oval or elongated brown pustules on upper and lower surfaces of leaves. This disease can be controlled by cultivating resistant hybrids or application of appropriate fungicides. The ear rot caused by *Giberella zeae* is fungal disease that enter through wounds to stalk or ear; ear rot is caused by the fungus infecting silks and moving down through the ear, and it can be controlled by providing adequate fertilization and irrigation that can help to reduce incidence of disease since stressed plants are more susceptible. Concerning the bacterial diseases, the maize is infected by *Erwinia chrysanthemi* which cause the bacterial stalk rot and its symptoms are the bending of the plants to lie on the ground (lodge) since the internodes above the soil turn to brown and be soft. The disease is controlled by enhancing the soil drainage. In addition, maize plants is infected by *Pseudomonas rubrilineans* that cause the bacterial leaf blight disease, and its symptoms are the formation of Water-soaked linear lesions on leaves, these lesions turn brown and may subsequently turn gray or white; lesions may have a red border. It can be controlled by planting resistant hybris of maize (KWS, 2018; Plant village, 2020).

Harvesting:

Maize is harvested mechanically or manually by hand harvesting (Du Plessis, 2003). ·

Part III: Postharvest handling

There are two ways or systems for postharvest management; timely harvesting or drying and late harvesting. Concerning the timely harvesting system, the cobs are detached from the plants and either dehusked or left in sheaths and in piles for transportation to the farm yard; then the drying process for the cobs takes place and after that the maize grains are stored in a safe storage place like the small metallic silos for different intervals of time; short-term storage (4-5 months), season long storage (6-9 months), long term storage (more than 9 months) (Mejía, 2003). In the drying or late harvesting system, the maize crop is dried in the field for 4-7 weeks after maturity, either in stalks or heaps and then it is harvested; cobs are detached from the plants and either dehusked or left in sheaths, then before transporting the yield to be stored, the crop must be dried at the farmyard. Maize crop, either in cobs or shelled, is kept in various storage structure or containers (Silos) (Mejía, 2003).

Part IV: Utilization

Maize is used for animal feeding, human consumption and alcohol production. Also, maize is used in some industrial applications such as oil, cornstarch, corn syrups, and other industrial applications. Maize contains starch, protein, and fat at percentages of 72 %, 10 % and 4 %, respectively; that supply energy of 365 Kcal/100 g. Maize also provides many vitamins such as vitamin B and essential minerals along with fiber while it is considered to be a poor source of calcium, folate, and iron (Ranum et al., 2014).

3.3.18 Melissa officinalis L. (lemon balm)

Part I: General aspects

Figure 3.38 General morphology of lemon balm

Classification:

Species: *Melissa officinalis* L. – lemon balm, common balm, balm mint, melissa balm

Family: Lamiaceae

Origin and distribution:

Lemon balm (see also Figure 3.38) is originally from Southern Europe (the Mediterranean region), North Africa and Western Asia. The lemon balm is now cultivated all over the world (DAFF, 2012).

Production levels:

The lemon balm yield of fresh plants is about 10 -25 t/ha, which produce about 3 – 7.5 kg oil/ha since the oil percentage in the plant leaves varies from 0.01-0.13% (DAFF, 2012). The main producers of the herb are Hungary, Egypt and Italy, while for the essential oil is Ireland (Fairman, 1992).

Description of the plant:

The lemon balm is a perennial herbaceous plant; it has a distinct fragrant lemon scent and taste. Its stem grows to reach about 30-60 cm height, the leaves are arranged in opposite pairs; each node carry pair of leaves. The leaves are ovate or heart-shaped serrated leaves, 3-5 cm long. Concerning blooming, white flowers carried on a bunch emerged from the axillary buds on the plant (DAFF, 2012).

Climatic requirements:

The lemon balm plant thrives in sunny conditions; it should be cultivated in temperate and subtropical regions since it can grow at temperature range of 15 to 35°C (DAFF, 2012).

Soil requirements:

Lemon balm can grow sandy and loamy fertile soils, well drained and at pH range 5 to 7.5 but it grows best in alluvial soil (DAFF, 2012).

Part II: Cultivation practices

Propagation:

Lemon balm can be propagated by seeds or by stolons. The seeds can be direct cultivated in the field or it is sown in the nursery to produce seedlings that later can be transplanted in the field (DAFF, 2012). The planting by using stolons is faster and easier compared to the sowing of the seeds. The direct seeding is applied in the spring or early autumn and it takes about 7-9 kg of seeds to cultivate hectare**.** The seeds are tiny so it must be cultivated shallowly in the soil.

Soil preparation:

Site selection is very important; it is better to cultivate it at well drained soils. Soil tillage improves the soil conditions.

Planting:

The number of lemon balm plants in the field varies between 45,000 to 100,000 plant/ha**,** the distance between the rows is 50-75 cm, and 20-30 cm between plants within the same row (DAFF, 2012). Also, it can be planted in beds with width 1.2 m. Since the lemon balm is a perennial plant, it can stay in the field for about 10 years, but usually it is replaced with another crop in the crop rotation after 5 years.

Fertilization:

In order to calculate the nutrient quantities that the plants need, soil and leaf analysis must be carried out. Rashed (2012) mentioned that the fertilization doses applied to lemon balm should be about 74 kg N, 75 kg P_2O_5 and 57.6 kg K_2O /ha, applying twice, at the first and second irrigation, and then repeat it after the harvest.

Irrigation:

Concerning the water requirements for lemon balm, it requires 500 to 600 mm precipitation which is distributed throughout the growing season, otherwise it should be irrigated by overhead sprinkler irrigation. (Moradkhani et al., 2010).

Disease control:

The lemon balm is infected by several diseases; it is susceptible to powdery mildew which is fungal disease caused by *Golovinomyces biocellatus*. The symptoms of the powdery mildew are the dusty-white to grey coating over leaf surfaces and plant parts. It can be controlled by avoiding factors that increase the relative humidity such as overhead irrigation, and by avoiding the late summer application of nitrogen fertilizers that increase the production of succulent tissues and leaves which are more liable for the infection with the fungus; finally chemical fungicides can be used for protection by spraying every 7-14 days throughout the growing season. In addition, the lemon balm is infected with another fungal pathogen which causes Septoria leaf spot disease, its symptoms are the brown or black 1-2 mm angular leaf spots. The high relative humidity and warm temperatures are factors that increase the infection, but it can be controlled by increasing the planting distances to ensure good air circulation and the crop rotation. (Meyers, 2007; DAFF, 2012).

Harvesting:

Concerning the lemon balm plants harvest, the aerial parts are harvested from the beginning of the summer, but the perfect time of harvesting is before the flowers open since at this time the highest concentration of volatile oil is found. Harvesting is done by hand on a clear, warm day, as the leaves will turn black if harvested wet or it can be cut with a mechanical cutter (DAFF, 2012).

Part III: Postharvest handling

After harvesting of the plants, sorting process takes place; the foliage is left in shade place to dry, avoiding the direct sunlight since it will cause the volatile compounds to diminish. Then, the distillation process is carried out, on the dried plant material by steam distillation or chemical extraction methods; either wise the distillation process can be applied directly after the harvest before drying (DAFF, 2012). Many factors affect the quality of the essential oil such as the moisture content of the plant material and the absence of mold. The lemon balm essential oil is characterized by the fresh lemon odor, and light yellow color. The main components of the essential oil are citronellal, citral (citronellol, linalool) and geranial in percentages of 39%, 33% and 2%, respectively. Also, the essential oil contains phenol carbon-acid (rosmarinic acid), and flavonglychoside acids in low concentrations (Moradkhani et al., 2010).

The dried foliage can be stored, when packaged in bags that allow air flow, to avoid the mold and fungus. Concerning the storage of the volatile oil, many containers can be used for packaging such as ceramic, dark colored glass, and to avoid oxidation of the oil it is preferable to keep it at cool area and in sealed containers away from light (Moradkhani et al., 2010).

Part IV: Utilization

The lemon balm has been many uses: it is used in cosmetic industries as it contains hydrosol which is added to clay masks to aid the skin healing; to improve mood and cognitive function; it helps to relieve sleep disorders such as insomnia and also, it relieves indigestion, dyspepsia and nausea. In addition, it is used at culinary purposes, the fresh leaves are used add flavor to many meals. The fresh or dry leaves are used as tea (Meyers, 2007; DAFF, 2012; Wilson, 2017).

3.3.19 Valeriana officinalis L. (valerian)

Part I: General aspects

Figure 3.39 General morphology of valerian

Classification:

Species: *Valeriana officinalis* L. – valerian, garden valerian

Family: Caprifoliaceae

Origin and distribution:

Valerian (see also Figure 3.39) is a perennial plant which is native to Europe and Western Asia; also it is cultivated in a commercial scale at America and Australia (Janke and DeArmond, 2004).

Production levels:

The yield of valerian plants is about 4-5 t/ha of dry weight for roots (Great South, 2019). It is the fourth best-selling medicinal herb in Europe with retail sales of US$ 200 million (Wiśniewski et al, 2016).

Description of the plant:

The valerian plant parts such as the leaves, stem, flowers, and roots are scented. The plant grows to reach about 150 cm height at blooming stage. It produces hermaphrodite white to pale pink flowers in branched panicles which are pollinated by butterflies and bees. The leaves are opposite, odd-pinnate, with each leaf having 7-10 pairs of toothed leaflets. It produces white roots up to 0.5 cm wide and 30 cm long. Also, the plant is consumed as food by the larvae of some Lepidoptera (butterfly and moth) (Janke and DeArmond, 2004; PFAF, 2010; Missouri Botanical Garden Website).

Climatic requirements:

The valerian plants prefer partial shade. The plants tolerate full sun and shade. The seeds need 20 to 21°C for germination. Valerian plants need to grow in moist conditions (Janke and DeArmond, 2004; Gardeners HQ Website).

Soil requirements:

The valerian plants can grow in various soils type. It grows in damp location;, however, it can also be found in drier soils. The best soil is the heavy fertile loams with high humus soils with adequate moisture but well-drained (Janke and DeArmond, 2004; Bioafrica website).

Part II: Cultivation practices

Propagation:

The valerian plants can be easily propagated by seeds. The seeds can be cultivated in Spring. The seeds should be sown in fine tilth, weed-free soil (Bioafrica website)

Soil preparation:

Site selection is very important; it is better to cultivate it at well drained soils. Soil tillage improves the soil conditions. Organic fertilization (compost – manure) can be applied to enhance the soil properties and increase the soil fertility, the fine tilth of the soil is preferred.

Planting:

The common valerian plants are cultivated by seeds. Planting one hectar of valerian plants needs about 3 kg of seeds (Bioafrica website). The planting spacing differs according to farming operation and the equipment used; generally it is cultivated at planting distance 30 -45 cm between plants within the same row, and 90 cm between rows (Johnny's selected seeds website).

Fertilization:

In order to calculate the nutrient quantities that the plants need, soil and leaf analysis are performed. The fertilization recommendations of valerian plants are 100-150 kg/ha of N are applied as doses during the growing season, While the phosphorus and potassium are applied at rates 100 kg/ha of P2O5 and 200 kg/ha of K_2O, during the soil preparation. In addition, a compound fertilizer with grade 15:10:10:8 N/P/K/S is applied at rate at 500 kg/ha (Bioafrica website)

Irrigation:

The water requirements for common valerian plants are moderate to heavy. It grows along ditches, rivers and damp woods. The plants thrive with annual precipitation of 24-28 inches per year (600-700 mm). In addition, artificial irrigation can be applied in order to supply the plants with its water requirements (Janke and DeArmond, 2004).

Disease control:

The valerian plants are infected by many pathogens, as powdery mildew that is caused by *Erysiphe polygan*. Its symptoms are the dusty-white to grey coating over leaf surfaces and the plant parts. It can be controlled by avoiding factors that increase the relative humidity such as overhead irrigation. Also, downy mildew infects the valerian plants caused by (*Peronospora valerianae*). Other diseases that can infect the valerian plants are: adema, causing root rot and white mold, and sclerotinia that rots the roots, caused by *Sclerotinia sclerotiorum.* These diseases are fungal and form brown to dark lesions above the soil line, rotting of the roots and rapid wilting of the plant. The fungus produces hard sclerotia that can survive in the soil and spores and can infect the aerial plant parts. It can be controlled by avoiding excess nitrogen fertilization applications, maintaining a crop rotation cycle for at least 3 years and removing infected plants immediately (Janke and DeArmond, 2004).

Harvesting:

The roots are the part of the plant that is economically exploitable. Roots are harvested during autumn in the first year, after the tops have been cut off and removed. The roots can be harvested either manually by hand or by using root crop lifter that can work to 30 cm depth. Dry soil conditions are desirable before washing (Great South, 2019).

Part III: Postharvest handling

After harvesting of the plant roots, mechanical shaking is desirable to remove the excess soil before washing. There are large thin-walled cells in the hypodermis of the rhizome where the essential oil is located. So, careful handling of the roots is essential in order not to damage these cells. In addition, excess washing of the roots can result in a reduction of bioactive components (Bioafrica website).

Since the volatile oil and components are sensitive to heat, the drying temperature must not be high in order to protect the oil content and structure. The drying process of the roots are performed by many techniques; drying at 40°C with a flow rate of 0.05 kg/sec/m^2, drying at room temperature (20°C) for 10 days, shade drying at 45°C, low temperature vacuum-drying, and freeze-drying. It is reported that essential oil content in the roots is decreased by 50% when dried at 50°C as compared with drying at 20°C. (Pilerood and Prakash, 2013; Bioafrica website)

Part IV: Utilization

Valerian oil is obtained from steam distillation of the dried and ground roots. The oil is used in flavor, pharmaceutical and fragrance industries (Great South, 2019; WebMD).

The active ingredients of valerian are called valepotriates which have calming effects, so it is used for sleep disorders especially insomnia. In addition, the root is antispasmodic, carminative, diuretic, hypnotic, powerfully nervine, sedative and stimulant (Great South, 2019; WebMD).

3.4 Non-edible Shrubs

3.4.1 Nerium oleander (oleander)

Part I: General aspects

Classification:

Species name: *Nerium oleander* belongs to Apocynaceae family, widely known as nerium or oleander

Family: Apocynaceae

Figure 3.40 General morphology of oleander shrub

Origin and distribution:

Nerium oleander (see also Figure 3.40) is native in and naturalized from Mauritania, Morocco, and Portugal eastward through the Mediterranean region and the Sahara, to the Arabian peninsula, southern Asia, and as far east as Yunnan in southern parts of China (Inchem, 2005).

Description:

Nerium oleander is an evergreen shrub or small tree. Oleander grows to 2-6 m tall, with erect stems that splay outward as they mature; first-year stems have a glaucous bloom, while mature stems have a grayish bark. The leaves are in pairs or whorls of three, thick and leathery, dark-green, narrow lanceolate, 5-21 cm long and 1-3.5 cm broad. Leaves are light green and very glossy when young and change to a dull dark green/greenish gray during maturing. The flowers grow in clusters at the end of each branch; they are white, pink to red, 2.5-5 cm diameter, with a deeply 5-lobed fringed corolla round the central corolla tube. They are often, but not always, sweet-scented. The fruit is a long narrow pair of follicles 5-23 cm long, which splits open at maturity to release numerous downy seeds (https://en.wikipedia.org/wiki/Nerium).

Climate Requirements:

Oleander is a vigorous grower in warm subtropical regions. Oleander will tolerate occasional light frost down to −10°C (Huxley et al., 1992) though the leaves may be damaged. Cold temperatures can be tolerated usually up to -5°C (Phillips and Rix, 1984; Huxley et al., 1992).

Soil Requirements:

Oleander t can grow in clay and loam soils, and it is preferable to be cultivated in good-drained soil. The soil pH is not prohibitive as it can grow to acidic, alkaline or neutral conditions. (https://pfaf.org/user/Plant.aspx?LatinName=Nerium+oleander).

Part II: Cultivation practices

Propagation:

Seed can be sown during spring in a greenhouse (Dirr and Heuser, 1987). The seeds must be obtained from pods free from the bacterial disease 'oleander knot'(Dirr and Heuser, 1987). The grown pods that have best growing characteristics can be separated and then transferred to new pots in a greenhouse especially at the first cold period. In the following summer, these cultivated pods can be transferred again. Alternatively, semi-mature sor mature shoots in August to September can be used for cuttings preparations (Sheat, 1948).

Planting:

Hard or semi hard woodcuttings of 60 cm length are used for planting. Rooted cuttings can be planted during June to July in 30 x 30 x 30 cm pits dug at 2 x 2 m spacing which filled with FYM, red earth and soil. After cultivation the plants are irrigated when required and manured with 10 t FYM/ha during January and repeated in August. No chemical fertilizers are normally applied. (http://agritech.tnau.ac.in/horticulture/horti_flower%20crops_nerium.html).

Fertilization:

FYM at 20 t/ha is applied in 2 equal splits during January and August. Soil application of 2 kg each of Azospirillum and Phosphobacteria per ha at the time of planting is suggested. It can be mixed with 100kg of FYM and applied in pits (http://agritech.tnau.ac.in/horticulture/horti_flower%20crops_nerium.html).

Irrigation:

It is important to keep a high moisture level during the root growth phase. But take care not to drown the cutting, or it might rot.

The water requirements follow sun exposure and temperature. If the oleander is in its colder winter quarters, its water needs are low.

During hot periods the oleander should also be watered, additionally to the regular watering, into its saucer, so that the plant is constantly in water.

Big plants may need tobe watered up to three times a day. The soil must be permanently alkaline (INCHEM , 2005).

Disease control:

Oleanders generally have no serious insect or disease problems.

Other cultivation practices:

Oleander generally requires pruning to obtain the best flowering. Suckers often develop along the lower portions of main stems or from roots.

Harvest:

Harvesting of flowers can be done from fourth month after planting. The fully developed and open flower buds are harvested. Harvesting time is early morning and late evening. An approximate yield of 100 -125 kg of flowers/ha/day can be obtained (https://dfr.icar.gov.in/Content/Pdf/NERIUM.pdf.

Part III: Post-harvest handling

Before packing, flowers should be dried. Packing must ensure protection of flowers against physical damage, water loss and external conditions detrimental to transported flowers. The relative humidity of the air during precooling and shipment of cut flowers should be maintained at the level of 95-98%. Lack of light during prolonged transportation at high temperature can cause yellowing of leaves in many flowers. For short distance and time period shorter than 20 hrs, cut flowers may be transported in insulated trucks without refrigeration after precooling and proper packing.

Part IV: Utilization

Flowers and leaves of oleander are used as diaphoretic, emetic, cardiotonic, sternutatory and expectorant agent (Chiej, 1984; Duke and Ayensu, 1985). The extract produced by soaking leaves is used externally for treating scabies (Chiej, 1984) and also as anti-oedematous agent (Chopra et al., 1986). The plant is considered poison as it has cardiotoxins (Chopra et al., 1986), so, the over-expose to it should be avoided (Chiej, 1984). Paste prepared from plant is used in treating ulcers of penis (Chopra et al., 1986). Roots are used as resolvent material whereas root bark oil is used in treating skin diseases and leprosy (Chopra et al., 1986). In addition, the plant showed anti-cancer ability (Duke. and Ayensu, 1985). Oleander is also used as anti-rodent (Uphof, 1959), anti-parasite (Chiej, 1984) and the leaves are used as insecticide (Polunin, 1969; Manandhar, 2002). In Mediterranean region, it is used widely for hedging (Polunin and Huxley, 1987; Huxley, 1992). Latex is also obtained from its leaves (Vines, 1982). The root system is used as stabilizer for soil in hot areas (Niebuhr, 1970).

3.4.2 Olea oleaster L. (wild olives)

Part I: General Aspects

Classification:

Species name: *Olea oleaster* L. - widely known as wild olive

Family: Lamiaceae

Figure 3.41 General morphology of the leaves of wild olives shrubs

Origin and Distribution:

The olive (see also Figure 3.41) is native to the Mediterranean region, tropical and central Asia and various parts of Africa. Wild Olive has large common distribution areas in the Middle East and in the Mediterranean Basin (Zohary and Spicgel-Roy 1975; Zohary, 1994). The wild olive tree thrives along the Mediterranean coasts. It is genuine in Spain, continental France and Corsica, continental Italy, Sardinia and Sicily islands, Greece and Turkey with Cyprus Island, and in all the east and south Mediterranean countries (Jordan, Lebanon, Syria, Israel, Egypt (Sinai) and Libya). (http://cdn.intechopen.com/pdfs/41365/InTech-Origin_and_history_of_the_olive.pdf.).

Description of the plant:

Oleasters differ from cultivated olives only by their smaller fruits, their lower oil content and, often, by their shorter leaves. At the juvenile stage, oleaster olives also show spiny shoots.

Climatic requirements:

Olive cultivars (*Olea europaea* L. subsp. europaea) and wild olives (oleaster olives) (*Olea europaea* L. subsp. sylvestris) show similar climatic requirements (Zohary & Spicgel-Roy 1975 and references therein, Zohary 1994).

Generally, Olives are grown in a wide range of climates in many different countries. The crop is mainly distributed between 25° – 40° North and South latitudes. The crop requires:

- Mild to cool winters with a chilling period of about two months, with average temperatures varying between 1.5°C to 10.0°C for flower bud differentiation.
- No late spring frosts that may kill the blossoms.
- Long, hot and dry summers to properly ripen the fruit.

It is, therefore, best suited to a Mediterranean-type climate. Some olive varieties, such as those grown in Egypt, Tunisia or Israel, bloom and fruit with very little winter chilling, whilst other varieties require more chilling for a normal flower differentiation. (https://www.haifa-group.com/olives-fertilizer/crop-guide-growing-olives)

Soil requirements:

Olives grow well on almost any well-drained and aerated soil with pH values of 6.5-8.5. Therefore, sites where water stands during rainy periods or where ground water is shallower than 1.2 meters deep should be avoided. Olive trees are tolerant to mild saline conditions, but extremely salty or sodic soils should be avoided. Olives have a relatively shallow root system and consequently they only require a 1.0-1.5 meter deep soil profile without any serious physical limitations. Olives prefer moderately fine textured soils ranging from sandy to silty clay, loamy soils. (https://www.haifa-group.com/olives-fertilizer/crop-guide-growing-olives)

Part II: Cultivation Practices

Propagation:

Nowadays, semi-hardcuttings is used in olive propagation that represented 60% of total propagation while grafting method represented 40% as well as micropropagation. Offsprings produced from sexual production did not have characteristics of parent and are considered unreproductive for their intials. Direct multiplication can be performed using ovules, cuttings, stems and layering. The method of multiplication depends on region, but the wide-spread method is seeds. Semi-hardwood cuttings are also a common technique with mist spray which firstly introduced in 1954. This method increases relative humidity and retains cuttings turgid during process of root induction.

Soil preparation:

Equal parts of sand, manure and soil should be mixed for nursery. Seeds should be sieved and then put in 6 x 1 m in beds. Whereas in case of cuttings, they have to be rolled after one month with soil mixture using cow dung or manure. The positions for performing new groves should be carefully cleaned with ploughing in depth. Sloppy land needs to be terraced.

Planting:

For cultivation using seeds, four kilograms can be sawn in 1 m^2. Seeds can be put closely and then covered with 1-2 cm in thickness of sieved mixture.

Seeds must be irrigated twice per week depending on moist. See beds should be covered with sheets to save them from rains and cold. Plastic sheet covers can be removed in shiny days. Within three months of sowing, seeds will be germinated and become suitable for budding and grafting one year later.

Pieces of roots weighing two to five kilograms and 5-10 cm in diameter can be put into soil at winter or at fall. Shoots from root pieces, cuttings, (200-400 g) can be put in bags from plastic material. Root cuttings are usually used for supplying another area with planting materials. The modified technique of root piece can be performed as following; branches (5-7 cm in diameter) with 40 cm height are used. The two-third parts of the branch are buried below the soil level at the permanent site and one-third of the top portion is exposed above the soil. This technique can be used in both fall and spring. In fall season, two years old stem that have 1-2 cm in diameter with 20-30 cm in length are used. About 2-3 cuttings prepared from stem can be put in the same plastic bag that contains equal quantities of soil, manure and sand and then they should be irrigated weekly (if there is no rain). Plants are separated and then must be put individually to produce good root system and grow. To decrease transplanting shocks, olive trees are cultivated in plane soil.

Olive tree (1-2 years age) directly after dug of pit (40 x 40 cm). The common spacing for planting is varied from 10-12 m in between plants up to 24 m in semi desert area. Nowadays, it is common between growers to plant in close area (6 x 5 m or 6 x 6 m) to get three hundred plants for one hectare. In cold regions, it is usually planted with high density to prevent death of plants by freezing conditions, therefore, orchardists plant two trees in pit doubling.

Fertilization:

To produce one tonne of olive nine kilograms of nitrogen, ten kilograms of potassium and two kilograms of phosphorus should be applied. Olive uptake per hectare is approximately as following; 8-20 kg P_2O_5, 20-50 kg K_2O and 17-33 kg nitrogen with ratio of 1: 2.5: 2, respectively. This amount depends on moist, temperature and soil. At plant critical times, plant should be supplied with nitrogen. Fertilizers should disperse outside treetop vertical projection and overturned at a 10-15 cm in depth by meaning of tillage. Manure is applied at 5-10 t/ha in dry climate and growers should repeat this application yearly or every two years while in humid climate it should be applied every three or four years. Application of manure with legumes is considered as excellent practice.

Irrigation:

Olive tree is considered as drought tolerant plant. Its water requirements are low and it produces bumper crop. It should be irrigated in critical times, 2-3 weeks before flowering, directly after flowering and fruit setting, at pit hardening, with full size fruit and coloring of fruit. In case of minimum rainfall limit (400 mm), there are two irrigation times in March.

Disease control:

Two fungal diseases are recorded for olive. Anthracnose results in huge loss of fruit production. This infection can be observed firstly by the brown to red spots on clusters and then by the nonflower opening. The other disease is leaf spot which occurred in orchards and spreads with dense planting. It is appeared as dirty faint spots at the two leaf surfaces and then leaf turns into yellow color caused by death of tree shoots. In addition, tree is sensitive to soil borne disease which is usually appeared with poor regime of water. In contrast, continues rainfall can help in acceleration and spreading of fungal disease. Controlling conditions in orchards can help avoiding fungal diseases.

Other cultivation practices:

Like cultivated trees, yearly suitable pruning at the same time is considered enforcement factor for good yield and to maintain a good balance of fruit /leaves/wood ratio.

Harvesting:

Harvesting is considered as an expensive process in olive production as it represented 40% of production cost. Table olives must be picked manually as flowers which picked individually and then should be placed in bags that lined with foam rubber. Picking should be carried carefully to avoid fruit damage. On the other hand, olive fruits that will be used for oil production can be collected using nets placed under trees. The harvesting time is from February to July. Generally, harvest time depends on targeted cultivar. Fruits are used as green; therefore, they have to be collected at bright green and before turn into yellowish-green or when the first light pink or purple blush is appeared. The targeted fruit with preferred size should be collected only while others can be collected later.

Part III: post-harvest handling

The picked olive should be directly packed after harvesting without delaying. The containers used in transferring table olives are smaller than those of olive collected for oil production. These small containers should be lined with foam rubber to avoid fruit damage and then they may be classified into classes according to size. Any stalks, leaves, malformed, bruised, infested and overripe fruit should be removed. As olive fruits are susceptible and may rapidly decay, all processes should be carried out carefully with workers with experience in this and it is plausible to be processed within 24 hours of harvesting. Undamaged fruit could be cool- stored for a limited period at a temperature of 10°C.

Part IV: Utilization

The leaves can be used as a substitute for tea. The plant has antipruritic, antiseptic, astringent, cholagogue, emollient, antipyretic, hypoglycaemic, laxative and sedative properties. It is used in the form of herbal tea for the treatment of peptic ulcer, as well to reduce blood sugar levels, and as sedative against nervous tension and hypertension (external application in the form of oil). It is applied externally to the skin against itching, bites, burns, abrasions, as well as hair tonic and antidandruff. In folk medicine of some countries the bark, from which is isolated a gum, is used as healing.

Olives are consumed either as olive oil or table olives (Kanakis et al., 2013). Olive oil market is very significant in the olive industry as approximately 90% of annually produced olives go for oil processing (Sibbet et al., 2005). Table olives and olive oil are v important in industrial sectors of Palestine, Israel, Spain, and other Mediterranean areas. Spain is the largest producer of olives followed by Italy and Greece.

3.4.3 *Echinacea purpurea* L. Moench (echinacea)

Part I: General aspects

Figure 3.42 General morphology of echinacea

Classification:

Species *Echinacea purpurea* (L.) Moench

Eastern purple coneflower or echinacea

Family: Asteraceae

Origin and distribution:

Eastern purple coneflower (see also Figure 3.42) is a perennial plant which is originated from North America in the center and east regions (AAFRD, 2005).

Production levels:

The yield of eastern purple coneflower is about 2.82-3.4 t/ha after 3 years growth (Kaiser et al., 2016). Letchamo et al. (2002) mentioned that the highest echinacea yields are reported in California (8500 kg/ha) while the cichoric acid content is recorded at an average yield of 195 kg/ha.

Description of the plant:

The Eastern purple coneflower grows up to 120 cm height and it blooms throughout summer into autumn. It produces purple (purple in the wild) to white flowers (ray flowers) arranged in a capitulum inflorescence. The flowers are hermaphroditic which are pollinated by butterflies and bees. The leaves are oval, toothed and carried on the stem alternately. The plant's economic exploitable parts are the roots and shoot which contain the active components (Stevens, 2000; Letchamo et al., 2002; Kaiser et al., 2016).

Climatic requirements:

The eastern purple coneflower plants grow in prairies; they thrive in hot and dry climates but also can grow in a wide range of temperature and humidity. In addition, they are frost resistant as they can survive at -40 ˚C (AAFRD, (2005).

Soil requirements:

The eastern purple coneflower plants can grow in various soil types, but the best soil is the well-drained, fertile with good water holding capacity. Poorly drained soils encourage the infection of the plants with pathogens especially the fungal ones. Soil pH can range from 6.5 to 7.2 but echinacea thrives in alluvial soil (AAFRD, 2005; Shadow, 2017).

Part II: Cultivation practices

Propagation:

The eastern purple coneflower plants can be easily propagated by seeds or by division of the crowns (Stevens, 2000). The seeds can be cultivated in Spring without cold stratification. The germination percentages are improved by giving seeds 1-4 weeks cold, moist stratification in peat moss or sand at 0 to 5°C (cold stratification), and the easiest way to sow the seeds is to cultivate them it trays outdoors in the fall in order to take its cold requirements (Lannotti, 2020). It is better to establish a field of Echinacea with transplants rather than the direct seeding in the field because it is more successful, so it is recommended to cultivate the seeds in containers or trays and then transplant them.

Soil preparation:

Site selection is very important; it is better to cultivate echinacea at well drained soils. Soil tillage improves the soil conditions. Organic fertilization (compost – manure) can be applied to enhance the soil properties and increase the soil fertility (AAFRD, 2005; Shadow, 2017; Lannotti, 2020).

Planting:

The number of eastern purple coneflower plants in the field varies depending on the planting distance; the distance between the rows is 60 cm, and 30 cm between plants within the same row (Stevens, 2000). In general, the plant density is about 54,500 plants/ha row (Stevens, 2000). It can be planted in beds with width 1.2 m.

Fertilization:

In order to calculate the nutrient quantities that the plants need, soil and leaf analysis must be carried out. The echinacea plants have low fertilization requirements and it is not necessary to be fertilized;also if the field is not pre-planted weed managed, the fertilizer applications will enhance the weeds growth that will compete with the echinacea plants (Shadow, 2017). On the other hand, organic fertilization can be applied in order to enhance the soil quality (AAFRD, 2005). In general, the recommended fertilization rates for the plants are 112 kg/ha of N, 56 kg/ha of P_2O_5, 168-224 kg/ha of K_2O, 22-34 kg/ha of sulphur and 8-10 ppm of iron (AAFRD, 2005).

Irrigation:

Concerning the water requirements for eastern purple coneflower plants, the plants thrive with annual precipitation 12-32 inches per year (300–800 mm). In addition, artificial irrigation can be applied in order to supply the plants with its water requirements. The irrigation is critical to the young seedlings to establish and grow well (AAFRD, 2005).

Disease control:

The Echinacea plants is infected by several diseases; it is infected by *Phymatotrichum omnivorum* which cause root rot; also usual is the sclerotinia stem rot which is caused by *Sclerotinia sclerotiorum.* These diseases are from fungal that form brown to dark lesions above the soil line, rotting of the roots and rapid wilting of the plant. The fungus produces hard sclerotia that can survive in the soil and also spores that can infect the aerial plant parts. It can be controlled by avoiding excess nitrogen fertilization applications, maintaining a crop rotation cycle at least 3 years and removing infected plants immediately. The plants can be also infected by several pathogens that cause damping of the plants such as *Rhizoctonia solani*, *Fusarium* sp., *Pythium* sp. and *Alternaria* sp. The damping symptoms are a sudden wilt for the young plants, the root tips are turned to black and if the plants are infected by Pythium, the seeds may not germinate. It can be controlled by cultivating in clean media free of pathogen spores or mycelium, ensure well drainage in the soil and water with adequate quantities. In addition, it may be infected by *Fusariuum oxysporum* that cause root rot since the pathogen invade the plant through wounds; also, the wet soils encourage the spread of the disease. Moreover, Alternaria leaf spot caused by *Alternaria* sp. can infect the plants. Fungicide can be used to control these diseases that are sprayed on the aerial parts or applied in the soil as protective application or as cure from these diseases (AAFRD, 2005).

Harvesting:

The eastern purple coneflower plants take 3-4 years for roots to reach harvestable size (Stevens, 2000). Roots can be harvested in the fall with a modified potato digger (Kaiser et al., 2016) and then chopped into sections before washing. Drying is accomplished by leaving roots in the field to dry naturally or by using an industrial drier (Kaiser et al., 2016).

Part III: Postharvest handling

After the harvesting of the plant roots, they are chopped and then washed. Drying is taking place after, either by leaving roots in the field to dry naturally or by using an industrial drier at about 30°C with constant air flow (Kaiser et al., 2016). During drying process, it is preferable not to expose the Echinacea roots to direct sunlight which can reduce the bioactive components such as echinacoside (AAFRD, 2005). In addition, the purple coneflower is often grown simply for its ornamental value, especially for its showy flowers.

Part IV: Utilization

The purple coneflower is grown for its aesthetic value, especially for its flowers. Also, it is used to stimulate the immune system since it has antimicrobial, anti-inflammatory and antioxidant properties. The extract of the whole plant and roots contain glycosides such as echinacoside, echinacin, phenyl propanoids such as caffeic acid, 217lavonoids such as luteolin, kaempferol, quercetin and many other bioactive compounds such as Alkamides, alkaloids, chicoric acid Polyacetylenes and Polysaccharides (AAFRD, 2005; Gupta et al., 2012). These compounds have immunostimulating properties, so it is used in virus infections such as the common cold and flu (WebMD electronic site).

3.5 Dry-soil Plants

3.5.1 Agave americana L. (American aloe)

Part I: General aspects

Classification:

Scientific name: *Agave americana* L

Common name: Agave, American century, American aloe, sentry plant

Family: Asparagaceae

Figure 3.43 General morphology of the American aloe plant

Origin and distribution:

The *Agave americana* (see also Figure 3.43) is native to Mexico, and the United States in New Mexico, Arizona and Texas. Nowadays, it is cultivated as an ornamental plant all over the world. It has become naturalized in many regions, including the West Indies, parts of South America, the southern Mediterranean Basin (at North African countries), and parts of Africa, India, China, Thailand (Govaerts, 2020; USDA, 2019 b). The plant arrived at Europe in the 16th century.

Iamonico (2019) mentioned that the American century plant is distributed in many regions in Africa. It is cultivated at the east of Africa (Eritrea, Ethiopia, Kenya and Tanzania), east southern Africa (Malawi, Zambia, Zimbabwe and Swaziland), and South Africa, in addition it is exist in North Africa (Libya, Algeria, Morocco). In South Africa, it is found in arid highland regions (Western Cape) (Plants Africa, 2020 electronic site)

Production levels:

The *Agave americana* L. is a fiber crop. These fibers are characterized by low density, high tenacity and high moisture absorbency. The fibers are extracted from leaves of the plant. The leaves of the plants from the 3rd year onwards are ready for harvesting and the older leaves with length not less than a meter are harvested. Each plant yields 40-50 leaves/year. In addition, the content of fiber varies from (2.5%-4.5%). The annual yield of agave is 300 t/ha (Hulleet et al., 2015) as the agave fibers yield is about 7 t/ha, and the world production is about 39,925 *tonnes* (FAOSTAT, 2017)

Description of the plant:

Agave americana L .is an evergreen, rosette, succulent and monocot plant which have a short stem, reaches about 1.5 m tall and spreads around 1.8-3 m. The plant typically lives only 10 to 30 years and at the end of its life the plant blossoms for only one time (semelparous nature) and then dies, but the plant produces suckers or adventitious shoots from the base, which continue its growth. The leaves are grey green coloured, sword shaped of stiff and sword-shaped. The leaves fold back on themselves; each leaf reach up to 2.5 m long and 20 cm wide and 5 cm thickness makes a dramatic statement in the landscape and is much favored for use in rock gardens (Gilman, 1999; Hulleet et al., 2015). The flowering stalk reaches about 8 m height carrying the flowers clusters at top which are much branched. The flowers are hermaphrodite, yellow or greenish-yellow in colour, reach 7-10.5 cm long and borne in an upright position. The fruit of the plant is large oblong capsule (Weeds of Australia, 2020 electronic site).

Climatic requirements:

Concerning the temperature, the american century plants can tolerate -3°C as the absolute minimum temperature, while the maximum temperature can be about 40°C. Generally, the mean annual preferable temperature is between 10°C to 30°C for the lower and upper limits, respectively (Iamonico, 2019). The american century plants can grow at USDA hardiness zones from 9 through 11 (Gilman, 1999). In addition, the annual preferable rainfall range is from 100-700 mm (Iamonico, 2019).

Soil requirements:

American century plant grows in dry and semiarid lands at elevations from sea level up to 2,500 m. It tolerates extreme drought, salt spray (maritime climate), high temperatures, poor soil and low fertility. It can grow on sandy and loamy soils, but prefers well-drained soil with pH ranging from 5.6 to 6.5 (Iamonico, 2019)

Part II: Cultivation practices

Propagation:

American century plants can be propagated by seeds; however, it is not a commonly used method because the plants take many years to flower and produce seeds. Nevertheless, the sexual propagation by seeds is very easy. Seed does not require a resting period and should be sown fresh andgerminates in 1-3 months at 20°C. Regarding the vegetative propagation, well-rooted suckers can be detached and used for propagating the agave plants and it considered the mainly method for propagation (Gilman, 1999; Iamonico, 2019)

Soil preparation:

It can grow on sandy and loamy soils but prefers well-drained soil with pH ranging from 5.6 to 6.5 (Iamonico, 2019). Soil tillage improves the soil conditions and is important to maintain relatively smooth, level ground for orchard work and harvesting. Organic matter can be added to the soil in order to improve the soil properties.

Planting:

The seedlings appear within days after sowing seeds. Growing of the seedlings can be done in pots of well-drained soil. Once well-rooted and after it reaches a height of 20 cm, plants can be transplanted in the permanent location. Mainly, suckers are used for propagation of American century plants that can be detached and planted at the nursery and then transplanted at the permanent site (Iamonico, 2019).

Fertilization:

The American century plants can grow in arid lands, infertile and poor soils. The plants can thrive on reduced water and fertilizer inputs. It can grow without adding fertilizers but, using slow-release fertilizers can ensure the constant supplement of the nutrients (Schoellhorn and Richardson, 2007).

Irrigation:

The American century plant is succulent which means that it is water-store adaptated. The preferable annual rainfall range is from 100-700 mm (Iamonico, 2019). Agave should be allowed to dry slightly between watering, because the key factor for good production is making sure the roots are aerated and for that the well-drained soil is preferable (Schoellhorn and Richardson, 2007).

Disease control:

The *Agave americana* L. plant is very resistant to diseases and pest infections. Some diseases can infect the plant such as bole rot disease, caused mainly by fungus (Aspergillus Niger) that enters the plant after harvesting and cutting of the leaves. Its symptom is wet rot, yellowish-brown coloured and soft, with a pinkishmargin, that can be lethal for the plant. This disease can be controlled by removing of infected material and harvesting under dry conditions. The agave snout weevils (Scyphophorus acupunctatus) attack the agave plants. The damage may occurres either by the adult or the larva. The larva bores into the young plant's bole, making a tunnel. Rotting follows and the plant dies. The adult weevil feeds at the axils of the upper most leaves, adjacent to the growing spike leading to staining of the fibers (Sisal production guideline, 2015).

Harvesting:

Concerning fiber extraction, the leaves of the plants from the 3rd year onwards are ready for harvesting. The leaves are collected from the plant manually. All lower leaves, standing at an angle of more than 45 degrees are cut away from the stem of the plant (Sisal production guideline, 2015).

Part III: Postharvest handling

After harvesting, the leaves are transported to the factory for fiber extraction either by mechanical or chemical processing. First of all, decortications process takes place to get rid of the external cortex of the leaves and have the internal fibers. This process is achieved by crushing the leaves between rollers and then mechanically scraped. After that retting process takes place by placing the fibers in water for about a week. Subsequently, the fibers are then washed and dried either in the sun or drying machines. Thereafter, these fibers are collected and brushed then graded according to the length (Hulleet. et al., 2015; Sisal production guideline, 2015).

Part IV: Utilization

In some countries, American century plants are grown as a fodder crop; leaves should ideally be dethroned to prevent injury before fed to cattle and other livestock. Leaves and roots are the most utilized parts of the plant. *Agave americana* L. plants are also used to brew an alcoholic liquor beverage (Gutiérrez-Uribe et al., 2017). It has medicinal uses for cardiac problems, high blood pressure, gastro-intestinal problems and rheumatic pain. The leaf juice is known to have anti-inflammatory, anti-bacterial and anti-fungal properties. The plant sap is used in Central America as a binding agent for various powders used as poultices on wounds, also the sap is used for treatment of diarrhoea, dysentery (Chevallier, 1996). In addition, gum from the root and leaf is used in the treatment of toothache. Besides, the root is diaphoretic and diuretic. The agave syrup has anticancerogenic and antioxidant properties (Bouazizet et al., 2014).

3.5.2 Juniperus communis (juniper)

Part I: General aspects

Classification:

Latin name: *Juniperus communis*

Common names: common juniper, Siberian juniper, dwarf juniper; genévrier commun

Family: Cupressaceae

Figure 3.44 General morphology of the juniper plant leaves and fruits

Origin and distribution:

Juniperus communis (see also Figure 3.44) is native to temperate Eurasia, and North America N of Mexico, occupying an extraordinary range of habitats (Farjon 2005). Among other places, it is native to Croatia; Sweden; and the United States. Also, Juniperus is a temperate species, which occurs in forests throughout Western Himalaya from Srinagar to Kumaon at 1700-4200 m MSL.

Description of the plant:

Juniperus communis is a small coniferous evergreen tree or shrub, very variable in form, ranging from 10 to rarely 16 m height to a low, often prostrate spreading shrub in exposed locations. It has needle-like leaves in whorls of three; the leaves are green, with a single white stomatal band on the inner surface. It never attains adult foliage. It is dioecious, with male and female cones, which are wind pollinated, on separate plants (Adams, 2004).

The fruit are berry-like cones, initially green, ripening in 18 months to purple-black with a blue waxy coating; they are spherical, 4-12 mm (0.16-0.47 in) diameter, and usually have three (occasionally six) fleshy fused scales, each scale with a single seed. The seeds are dispersed when birds eat the cones, digesting the fleshy scales and passing the hard, unwinged seeds in their droppings. The male cones are yellow, 2-3 mm (0.079-0.118 in) long and fall soon after shedding their pollen in March-April (Adams, 2004).

Climate Requirements:

It prefers temperate climate.

Soil Requirements:

Sandy, loamy and clay, well-drained soil is suitable for this plant, but can tolerate in heavy clay and nutritionally poor soils. *Juniperus communis* can grow in acid, neutral and basic soils and can survive in very acid and very alkaline soils.

Part II: Cultivation practices

Propagation:

Juniperus communis can be multiplied through stem cuttings and seeds; however, meristems and stem-cuttings are ideal material as plants propagated from stem-cuttings grow faster than that of seedlings.

The seed can be very slow to germinate because it has a hard seed coat so, the seed requires a period of cold stratification, followed by a warm period and then another cold spell, (each of 2-3 months duration). Also, soaking the seed for 3-6 seconds in boiling water may speed up the germination process.

Mature wood cuttings (5 -10 cm) can be used with a heel during September or October in a cold frame, panting them in the following autumn. Layering occurs in September or October and takes 12 months.

Soil preparation:

It is not necessary to plough the entire field for planting crop. The planting spots marked at desired space should be weed free before making planting pits of dimension 45 x 45 x 45 cm. Pits are filled with equal proportion of soil and sand. (http://vikaspedia.in/agriculture/crop-production/package-of-practices/medicinal-and-aromatic-plants/ juniperus-communis#section-4)

Planting:

The right time for collection of seeds is October for raising seedlings of J. communis. Moreover, success of seeds propagation is very poor. Hence, to multiply the plant through vegetative propagation is preferable. Stem cutting is suitable in May. Apical shoot (15 cm) performs better root formation than the older part of the stem. Sand is most suitable medium for planting. In propagation chamber or poly tunnel, the success rate of rooting is 40 to 57%. IBA 2500 ppm promotes rooting in maximum cuttings (80%) followed by IBA 3000 ppm (60%). Peeling of bark at the lower end of the cuttings improves the rate of success as compared to round or normal cut and crushing at the lower end. Normally, stem-cuttings take 60-70 days for rooting. The rooted stem cuttings should be hardened at least for 6 months before transplanting in field. In nursery, the stem-cuttings should be planted at 10 x 10 cm spacing.

July-August is the suitable period for planting rooted stem-cuttings or seedlings of plant in main field (http://vikaspedia.in). Sapling is planted at the centre of the pit and the soil is gently compressed after planting. The pits are made at a spacing of 1 x 1 m accommodating 10,000 plants/ha. Plants should be watered lightly after the planting.

Fertilizing:

Additional fertilizer is not necessary, except in the poorest of soils.

Irrigation:

In the absence of rainfall, irrigation at weekly interval is essential for about a month after transplanting to ensure establishment of the saplings in field. These drought tolerant plants should not be watered, except during a severe drought.

Disease control:

No disease or insect-pest has so far been noticed in this crop (Sheat, 1948)

Harvest:

Juniper communis bears flowers / fruits after attaining the age of about five years. Fruits rip during September-October, hence it is the right time to harvest the fruits. Bark and leaf can also be collected during October.

Part III: Postharvest handling

Bark, leaf and fruits can be air dried and stored at room temperature in a dry place.

Part IV: Utilization

Aerial parts were used for acute and chronic cystitis, albuminuria, catarrh of the bladder, renal suppression, leucorrhoea, and amenorrhoea. Fruits were used as antiseptic, stimulant, disinfectant, styptic, chronic Bright’s disease, migraine, dropsy, rheumatic and painful swellings, piles, and infantile tuberculosis. Bark was used in nephrotic dropsy of children, asthma, gonorrhoea, pulmonary blennorrhoea, arthritis, respiratory affections, diabetes, bladder affections, chronic pyelonephritis, cough, abdominal disorders, and skin affections. The whole plant was used as carminative, urinary antiseptic, diuretic, emmenagogue, sudorific, digestive, and as anti-inflammatory (Gumral et al., 2013; Banerjee et al., 2013; Pepeljnjak et al., 2005)

Juniper oil has been used as a carminative, in arthritis, as diuretic and as a steam inhalant in the management of bronchitis (Sati and Joshi, 2010; Takacsova et al., 1995).

Oil of Juniperus can be also used in aromatherapy, through inhalation, massage, ingestion to create good health and beauty and in perfume industries (Kılıç and Kocak, 2014).

Western American tribes combined the berries of Juniperus communis with Berberis root bark in a herbal tea. Native Americans also used juniper berries as a female contraceptive (1997).

3.5.3 Lavandula angustifolia (true lavender)

Part I: General aspects

Classification:

Scientific name: *Lavandula angustifolia*

Common names: true lavender, English lavender; French lavender; spike lavender

French or Spanish lavender; hybrids of L. angustifolia x L. latifolia are referred to as lavandin

Family: Lamiaceae

Figure 3.45 General morphology of the true lavender flower

Origin and distribution:

True lavender (see also Figure 3.45) is native to the Old World and is found from Cape Verde and the Canary Islands, Europe across to northern and eastern Africa, the Mediterranean, southwest Asia to southeast India. Many members of the genus are cultivated extensively in temperate climates as ornamental plants for garden and landscape use, for use as culinary herbs, and also commercially for the extraction of essential oils.

Production levels:

The world production of high-quality lavender oil is 200 metric tonnes per year while lavandin oil is 1,000 metric tonnes per years The price of lavandin is lower than for lavender oil. Bulgaria, England, France, Australia, USA, Canada, South Africa, Tanzania, Italy and Spain were at one point the major producing areas of lavender oil. True lavender is mainly cultivated in Europe, especially France where is used in perfume industry. Worldwide production of spike lavender oil is ranging from 150 to 200 tonnes per year.

Description of the Plant:

Lavender is the name given to several species of herbaceous, perennial shrubs in the genus Lavandula which are grown as ornamental plants or for essential oil. Lavender plants are small, branching and spreading shrubs with grey-green leaves and long flowering shoots. The leaves can be simple or pinnate measuring 30-50 mm in length. The plant produces flowers on shoots or spikes which can be 20-40 cm long. The flowers are lilac or blue in color. Lavender can grow to 0.4 m in height and live for 20-30 years. Lavender may also be referred to as true lavender, medical lavender, smelling lavender, thin-leaved lavender or English lavender and is believed to originate from the Mediterranean, Middle East and India (https://plantvillage.psu.edu/topics/lavender/infos).

Cultivars:

There are three main species within the genus producing lavender essential oil Such as L. angustifolia, L. latifolia and L. angustifolia x L. latifolia

Climatic requirements:

Lavender needs at least 6-8 hours of daily sun exposure and prefers warm and moderately dry climates, mild winters and sunny summers. The plant originated from Mediterranean countries, where average temperatures of 20-30°C during spring-early summer are common. Soil temperatures above 18°C favor growth and regeneration after harvest. However, the plant can tolerate lower temperatures as well. High humidity favors the development of fungal diseases, while extreme summer heat effects negatively the quality of products (floral stems, essential oil). It is necessary for all lavender growers to make extensive research on varieties that produce well locally. A variety that thrives in Southern California is most probably unsuitable for Canada and vice versa. Lavender can also thrive in high altitudes (up to 1500 meters) and inclined fields.

Soil requirements:

Lavender plants can grow in all well-drained soils. They can withstand pH from 5, 5 to 8. However, the best yields are often achieved in light and sandy soils with pH close to 7 and with very good drainage.

Part II: Cultivation practices

Propagation:

Lavender can be propagated by seeds or cuttings. In large scale cultivations, seeds should be used as because of their lower cost compared to cuttings but more time is needed for th plant to grow. Cuttings should be taken from healthy plants grown out of doors. Rooting hormonessuch as IBA can be used to encourage rooting. Cuttings of 10 to 15 cm in length are obtained from young top shoots. The bottom two thirds are stripped from leaves.

To propagate by layering, a long, healthy flexible stem should be selected, and 10 to 15 cm of foliage must be removed, leaving 10 cm of foliage at the tip of the branch. The bare section should then be covered with moist soil. The branch will root at the soillevel. Once rooted, new plants are cut from the mother plants. After the onset of roots (from 6 to 12 weeks), the plants can be replanted in the prepared land. A liquid organic feed can be given on a weekly basis.

Soil preparation:

The first step towards effective soil preparation is the soil analysis and pH. The soil pH should be corrected to desired levels (6.8-7.5). Moreover, the soil analysis will reveal any nutrient deficiencies, so that the farmer can take corrective actions under the guidance of a licensed agronomist.

Planting:

When planting with seeds, about 50 g of lavender seed are used to produce about 10,000 plants; so, 28-56 g of seeds per seedbed of 0.1 hectare (1,000 square meters).

The seeds are sowed indoors during the end of winter. Many lavender farmers mix the seeds with building sand and place the seed mix in the surface of the soil. The seedbeds or the pots need sunlight exposure. The temperature indoors should be close to 20°C. However, when germination is low 3 weeks after sowing, the temperature can be 5-10°C for 1 week.

Regardless, if seeds or cuttings are used, the plants should be arranged inside the row at a distance of 40-65 cm, according to the variety of the plant. The distance between rows ranges from 47-59 to 120-150 cm. On average, there are 18,000 to 22,000 lavender plants per hectare.

Fertilization:

Lavender plant generally needs more Nitrogen than Phosphorus and Potassium, in order to thrive and give high yields for many years. In most cases, the plant responds greatly to Nitrogen supply. However, supplying excessive quantities of Nitrogen will have a negative effect in the quality of essential oil, while it will favor the development of weeds.

A common fertilizer scheme applied by many conventional farmers involves adding 700 lbs. (318 kg) of N-P-K 20-10-10 per hectare every year (1 hectare = 2.47 acres = 10.000 square meters). Normally, this quantity is often split in 2 or 3 applications, with the first starting immediately after harvesting or pruning.

Organic lavender growers often add 8-10 tonnes of well-rotted manure per hectare and plow well before they transplant the young plants. Then, every 2-3 years, they add 5-6 tonnes of manure per hectare, most often during the autumn. They cultivate carefully so that they will not hurt the roots and irrigate well after every manure application if there are no autumn rainfalls. Slow-release organic fertilizers are also commonly used.

Irrigation:

Newly established plants (started from seeds or cuttings) need more water than mature plants. Young plants need artificial water supply in order to develop a strong root system. After 2 years, in many cases, mature plants rely solely on rainfalls, provided the annual precipitation exceeds 450 mm. However, this depends also on soil texture and humidity levels. Lavender plant often suffers from root rot and fungal diseases that are favored by excessive water, so over irrigation is forbidden. Also, the soil must be left to dry between watering sessions.

In areas with no frequent rainfalls, most farmers irrigate the plants in order to avoid a water stress before and after the flowering period. Such a stress just before the flowering period will have negative effect in the final yield. Many farmers apply 3-4 irrigation sessions during summer months, in areas with hot summer and no rainfalls. In other cases, drip irrigation is applied, and the plants are watered for 20 minutes once a week, especially 1-2 months before harvest (June-July in US). Most lavender growers irrigate through drop-by-drop technique down at the root. Spraying from overhead will most probably hurt the flowers and lower the quality of harvested product.

Disease control:

When grown in ideal conditions (full sun, free-draining calcium rich soil and low summer humidity) they are generally trouble free. In conditions other than these, fungal problems usually appear. Commonly it will be root rot and death of lower foliage making bushes look very scraggy. These fungal problems will be more apparent in older, less vigorous plants.Regular applications of eco-seaweed may help stave off fungal problems. (https://ecoorganicgarden.com.au/gardening-tips/how-to-grow-lavender/).

Other cultivation practices:

In the first 2 years flower buds must be pruned off to assist the plants to develop to their best potential. Pruning will have to be carried out after harvesting, in autumn because harvesting the flowers for oil leaves most of the stalks on the plants.

Harvesting:

Lavender grows slowly during the first year, and many farmers cut the flowering stems when the first buds open during the first growing season. Theharvesting usually occurs during summer (June-July in most areas of United States). Knowing when exactly to harvest lavender requires extensive experience and constant “trial and error” effort. Most farmers harvest when the buds have formed but most of the flowers have not yet opened. There are two rules of thumb when harvesting lavender. The first is that a sunny day with mild weather and no wind must be chosen for harvesting. A potential rainfall at the day of the harvest (or even 2-3 days before) will decrease the quality of the final product. Extreme heat and strong winds will also favor the evaporation of essential oil, so a portion of our product will be lost if it is too hot or windy. As a second rule of thumb, lavender for essential oil must be harvested about 5-10 days earlier than for floral stems.

There are several harvesting techniques, depending on which part of the plant is needed. For essential oil production, first only from flowers or both flower and leaves can be used nut theessential oil from flowers only is of higher quality.

Part III: Post-harvest handling

After harvesting, the herb is distilled to obtain the essential oil. The yield of the oil may be changed from one season to the next according to the weather and the age of the plants. Solvents, such as tolune, hexane and petroleum ether may be used to produce a smaller quantity of lavender and lavandin concretes. Concretes are used in the perfumery industry. Absolutes are more widely used in fine perfumery.

After harvesting the flowers, are tied in bundles and hung up to be dried in the shade. After drying the flowers are packed into boxes or cases lined with paper.

The oil should be kept in dark, air-tight glass bottles, fluorinated plastic, treated aluminum, and dark glass or ceramic containers and not exposed to heat or heavy metals.

Part IV: Utilization

The health benefits of lavender are impressive including, relieving stress and anxiety, improving mood and promoting restful sleep. Lavender’s anti-inflammatory qualities help to reduce irritation of the skin and may be used as a wound cleanser. The organic compounds and antioxidants in lavender are responsible for its relaxing qualities. Lavender’s polyphenols benefit the digestive tract by helping to prevent development of harmful intestinal flora and reduce bloating and cramping. It is used in soap industry, eau de cologne, candles, incense sachets, potpourri, wands, pillows, flower bundles, dried arrangements, wall hangings, wreaths and also as a detergent and cleaning agent.

3.5.4 Origanum vulgare (oregano)

Part I: General aspects

Figure 3.46. General morphology of oregano

Classification:

Scientific name: *Origanum vulgare*

Common names: oregano, wild marjoram (En), Mediterranean or European oregano (Am). Origan (Fr)

Family: Lamiaceae

Origin and distribution

Although *O. vulgare* (see also Figure 3.46) is considered as a plant with Mediterranean origin, it is commonly found in Europe and distributed throughout West and Central Asia as well as Taiwan. Additionally, it is cultivated in many countries all over the world including South-East Asia (e.g., Indonesia, the Philippines).

Oregano plays a primary role among temperate culinary herbs in world trade (Olivier, 1994), as more than 300,000 tonnes of oregano is consumed every year in the United States alone.

Plant Description

Origanum vulgare is a perennial growing to–0.6 m - 0.8 m height (Mabey, 1974) and is not frost tender. It produces flowers during July and September, while the seeds ripen during August and October. Leaves are arranged oppositely and are covered with plant hairs. Small flowers are characteristic for origanum and are borne in clusters; they range in color from white to pink or pale purple. The species is hermaphrodite (has both male and female organs) and is pollinated by Bees and Lepidoptera (Moths & Butterflies). It is noted for attracting wildlife.

Climatic requirements

The plant is favored in full sun but tolerates partial shade. Oregano can also grow indoors satisfactorily under standard fluorescent lamps, and exceptionally well under high output fluorescent, compact fluorescent, or high intensity discharge (metal halide or high pressure sodium) plant growing lights. The standard fluorescent lamps should be kept between 2 and 4 inches from the tops of the plants, high output and compact fluorescents approximately 0.3 m above the plants, and HID lights between 0.5 and 1.2 m above the plants, depending on wattage. An oscillating fan gently stir seedlings should be used for at least 2 hours per day to stimulate shorter, sturdier, and more natural plant habit.

Soil

Origanum is suitable for sandy, loamy and clay soils. It prefers well-drained soil and can also grow in nutritionally poor soil. Varied pH soil types are suitable for plant grow, basic, neutral and acid soils. Moist or dry soils are suitable for cultivation. The plant can also tolerate strong wind. (https://pfaf.org/user/Plant.aspx?LatinName=Origanum+vulgare).

Part II: cultivation practices

Propagation

Seeds are sown in early spring by just covering the seed with soil. Two weeks are usually required for germination. When the seedlings are large enough for handling should be pricked out in a solo pots. In early summer, seedlings can be planted out in field. Also, the seed can be sown in the field in late spring. Division is very easy in October and in March; larger divisions can be planted out directly into their permanent positions. It is preferable to pot small divisions for growing them under light shade in cold until planting in late period of spring while in June basal cuttings from young shoots can be easily prepared. Shoots accompanied with underground stems, 8-10 cm in height, can be harvested and then each one can be pot individually in cold and shade frame or greenhouse for well rooting until cultivation in summer (https://pfaf.org/user/Plant.aspx?LatinName=Origanum+vulgare).

Land preparation / soil requirements:

Growing oregano is normally successful in nearly any herb garden soil. However, it thrives at a soil pH of between 6.0 and 8.0. For optimal growing conditions, the garden soil should be slightly sandy, well-drained and friable (crumbly). Most annual herbs like a rich soil; maybe not *quite* as rich as vegetables need, but close enough so they can be planted in the same beds.

When planting herbs, the soil should be amended with a 2-3 in (ca. 5-7.5 cm) layer of garden compost or a 1-2 in (ca. 2.5-5.0 cm) layer of composted manure. The organic matter should be mixed into the soil with a shovel or hoe, or tilled in.

When compost is used instead of manure, addition of an organic nitrogen source like alfalfa is required.

Planting
It is recommended to carry out seedling transplanting for Origanum seeds as they are tiny (the 1000-seed weight is only 0.20-0.25 g). This is done in March-April on seeds planted in October in the seedbed. It is possible to carry out this operation also in autumn; however, as weather remains cold until March, frost damage could easily occur to the young plants. Distances of 50-60 cm between rows are advised, to permit hoeing and mechanical weeding. Plant density influences the yield and the weight of the plant. In the field, the results of an experiment have indicated an increase in plant biomass from 6.3 to 5.6 and 4.7 t/ha when using 40, 60 and 80 cm distances between rows respectively and from 6.3 to 5.3 and 5.0 t/ha when using 20, 30 and 40 cm within row respectively. Furthermore, plant weight changes from 350 to 366 and 403 g with 40, 60 and 80 cm between-row distances and from 306 to 361 and 452 g with 20, 30 and 40 cm within-row distances, respectively.

Fertilization

The fertilization levels suggested are 0.68-2.2 kg/ha nitrogen per day and 0.74-1.8 kg/ha potassium per da" in a "polyethylene mulch-micro-(trickle)-irrigation "ystem." Phosphorus is applied pre-planting at 21.3 kg/ha. (https://www.richters.com/show.cgi?page=QandA/Commercial/20080120-2.html).

Preparation of soil by digging in some compost or well-rotted manure eliminates the requirements for fertilizer. Ploughing of the soil and fertilization with ammonium phosphate during November to December is sufficient for oregano cultivation. Dordas (2009) reported that Foliar applications with Ca^{2+} and Mg^{2+} increased the Ca^{2+} and Mg^{2+} concentration of the leaves and increased plant height. Additionally, applications of Ca^{2+} and Mg^{2+} decreased the number of days required for oregano to flower by an average of 3-4 days; dry matter yield also increased by 22% with Ca^{2+} and Mg^{2+} during the 2-year study. Ca^{2+} and Mg^{2+} applications affect the essential oil yield, but do not affect the essential oil content.

Sotiropoulou and Karamanos (2010) studied the effects of nitrogen application on plant growth traits, biomass yield, oil concentration and oil yield of Greek oregano (*Origanum vulgare* ssp. Hirtum) during three cultivation periods following field establishment. The number of stems, branches and inflorescences per plant, LAI, dry matter, and oil yield were significantly affected by nitrogen levels above 40 kg ha^{-1}, showing an optimum mostly at 80 kg of N ha^{-1}. No nitrogen-effect on plant height and oil concentration was observed.

Karagiannidis et al. (2011) investigated the effect of arbuscular mycorrhizal fungi on the concentration of macro- and micronutrients in tissues, the quantity and quality of essential oils and the growth of oregano. Results suggest that the use of mycorrhizal fungi may allow plant growth in low fertility soils, reduce fertilizer inputs and increase aromatic plant production of essential oils. It was also indicated that it may be possible to use mycorrhizae to ameliorate the quality of the essential oil produced.

Irrigation:

Usually, origanum is cultivated under dry conditions. Winter rain is usually sufficient for the crop. To increase origanum yield and to carry out second cutting in fall, summer irrigation is required soon after cutting. Irrigation in spring is also plausible if there is no rain over a long period during the winter. (https://www.bioversityinternational.org/fileadmin/_migrated/uploads/tx_news/Oregano_199.pdf).

Disease control

No severe diseases are recorded in the literature for oregano.

Aphids are included in the pest recorder, and it can usually be remedied with insecticidal or horticultural soaps. Under normal conditions, pest control can be done with a simple weeding out (manually or by using pesticides) (Kintzios, 2002a; Makri, 2002); however, aphids, thrips and red spider mites may occasionally appear, requiring more severe measures (Csizinszky, 1992). There is scarce documentation on biological pest control in oregano, which needs frequent (e.g., at least four times a year) mechanical weed control (Chiapparo, 1997; Hammer and Junghanns, 1997).

Harvesting

Origanum is harvested at full blooming for essential oil production or at the beginning of blooming for herb production.

Part III: post-harvest handling

After harvesting, plants should then be dried in the shade. A 25-cm stack height is preferred during drying operations in order to facilitate the accumulation of etheric oil content. Natural drying is a common procedure for origanum, or else oven drying procedure is recommended at 30-35°C in commercial scale production. A moisture content of 7% (minimum) to 12% (maximum) is required.

The separation of dried leaves and spike-like inflorescences from stems is done by hand when the same quantity of material is involved (in large production, threshing machines are used). Combined threshing machines are usually preferred. Since volatile oil percentage gradually decreases after 4-5 months of storage, it should be kept in conditions of cool and relatively low humidity.

Part IV: Utilization

Oregano is a strong medicinal food that is recommended during winter illnesses and to support healthy digestive system function. Unproven folk medicine uses oregano for treatment for respiratory disorders, coughs, inflammation of the bronchial mucous membranes and as an expectorant. In China, it is used for colds, fever, vomiting, dysentery, jaundice, and malnutrition in children. Oil is strongly antiseptic for the skin. The plant’s essential oil and different extracts have been reported as antioxidant, antimicrobial, anti-inflammatory as well as hypolipidemic (Bhat et al., 2018; Elshafie et al., 2017; Leyva-López et al., 2017; Milos et al., 2000; Morshedloo et al., 2018; Soliman et al., 2016).

Raw or cooked leaves are used as a potherb (Mabey1974, Facciola, 1990). Also, they are used as a flavoring agent and are frequently included in flavored food with garlic, chillies, onions etc. (Facciola, 1990 and Bown 1995). Most commercially available dried oregano is not *Origanum vulgare* but a number of different, often, unrelated plants (Bown 1995). These include *Lippia graveolens, L.* palmeri and *Origanum syriacum*. Herb tea is prepared from the dried leaves and flowering stems (Facciola 1990, Coffey 1993 and Bown 1995).

Chemical composition of *Origanum* species and their volatile oils

Although many chemical compounds have been isolated from oregano, the most important group, from a commercial and application point of view, is the volatile oils, basically composed of terpenoids. However, composition may vary significantly among different genotypes. Oregano species are rich in phenolic monoterpenoids such as carvacrol (and secondarily thymol), while species rich in bicyclic monoterpenoids *cis*- and *trans*-sabinene hydrate are commercially designated as marjoram. It is quite easy to distinguish the difference between the pungent smell of oregano and the sweet smell of marjoram. In the first group are a number of chemically related compounds such as γ-terpinene, *p*-cymene, thymol and carvacrol methyl ethers, thymol and carvacrol acetates; also compounds such as *p*-cymenene, *p*-cymen-8-ol, *p*cymen-7-ol, thymoquinone and thymohydroquinone are also present. In the second group, α-thujene, sabinene, *cis*- and *trans*-sabinene hydrate acetates, *cis*- and *trans*-sabinol and sabina ketone can also be found (Skoula and Harborne, 2002).

Other chemical groups that are commonly detected in *Origanum* species are acyclic monoterpenoids such as geraniol, geranyl acetate, linalool, linalyl acetate and β-myrcene; bornane-type compounds such as camphene, camphor, borneol, and bornyl and isobornyl acetate; and sesquiterpenoids, such as β-caryophyllene, β-bisabolene, β-bourbonene, germacrene-D, bicyclogermacrene, α-humulene, α-muurolene, γ-muurolene, γ-cadinene, allo-aromadendrene, α-cubebene, α-copaene, α-cadinol, coryophyllene oxide and germacrene-D-4-ol.

3.5.5 Satureja thymbra L. (pink savory)

Part I: General aspects

Figure 3.47 Morphology of pink savory

Classification:

Species *Satureja thymbra* L. – pink savory, savory of Crete, whorled savory, thyme-leaved savory, pink savory, and Roman hyssop

Family: Lamiaceae

Origin and distribution:

The pink savory plants (see also Figure 3.47) are restricted to the Central and East Mediterranean regions and it considered to be a local aromatic medicinal plant that grow in the wild (Yaniv and Duadi, 2014). It grows in Mediterranean woodlands and scrubland.

Production levels:

There is no specific statistics for the area cultivated and productivity of the pink savory since it grows in the wild. Also, at the conventional cultivation, it is cultivated at small scales and farms.

Description of the plant:

The pink savory is an aromatic shrub that reaches 30-50 cm height, its shoots and branches are erect. The leaves are opposite, sessile and smooth. The flowers are arranged in inflorescence which are elongate and terminal consisting of 3-6 (or more) range from pink to purple. The plant fruit is schizocarp. This shrub is very common on rocky limestone gully, flowering nearly the whole year (El Beyrouthy et al., 2013)

Climatic requirements:

The pink savory plant grows well at sunny conditions. The plants suffer damage at temperatures below freezing but they can be grown as annuals plants, blooming and form seeds in their first year (El Beyrouthy et al., 2013; Temperate, 2019)

Soil requirements:

Pink savory plant prefers a neutral to alkaline soil and can grow at dry locations. It can grow at Coastal areas, low and medium mountains (ESCWA, 2010).

Part II: Cultivation practices

Propagation:

The pink savory plants are propagated by seeds which is cultivated not much deep in the soil, in April, in a greenhouse. Germination takes about month. Transplant of the seedlings in the pots is carried out individually as soon as they are large enough to handle. Seeds can be planted directly in the permanent field during summer but if the site area is of cold winter try, it is suggested to be grown on in a cold frame and planted out in the early spring of the following year (Temperate, 2019; Mountain valley grower's web site; Practical plants web site). In addition, cuttings of half-ripe wood, 5-8 cm can be used taken at a node and in July and August placed in pot during autumn and winter and then transplanted in the permanent filed in late spring or early summer of the following year. If it is propagated by cuttings of young wood, preferably with a heel, of April/May. Then they are transplanted in the summer if the plants are grown well, otherwise they are overwinter in a cold frame and planted out in late spring or early summer of the following year. (Temperate, 2019)

Soil preparation:

Site selection is very important; it is better to cultivate it at well drained soils. Soil tillage improves the soil conditions.

Planting:

Pink savory plants can be cultivated by sowing seeds in the permanent field or by transplanting the seedlings produced in the greenhouse. At the appropriate weather conditions, the germination of the seeds take about 1 month. Also, cuttings and division can be used to cultivate the pink savory plants (Temperate, 2019; Mountain valley grower's web site; Practical plants web site.). In general, savory plants are cultivated at planting distance 30-45 cm between plants within the same row and 60-80 cm between rows (Harvest to Table web site).

Fertilization:

The pink savory plants grow in the wild at various types of soils without chemical fertilization. Shiffler (2019) mentioned that there is no need to fertilize savory plants, but you can apply a weak dose of compound fertilizer at mid growing season.

Irrigation:

Regarding the water requirements, the savory plants need regular water supply until the plants are established (Shiffler, 2019).

Disease control:

The savory plants can be infected by diseases such as web blight that is caused by *Rhizoctonia solani.* Its symptoms are water-soaked lesions on stems, then on leaves and then blighted leaves turn brown (Garibaldi et al*.,* 2012). Also, the plants can be infected by aphids, spider mites and leafhoppers, which can be controlled by cultivating some plants that belong to Umbellifera family like carrot and daisy that considered to be hosts for their predators. Also, the insects like aphids can be washed by water or insecticidal soap and finally spraying appropriate insecticide to control these insects (Smart Gardener web site).

Harvesting:

Savory of Crete plants are harvested in June when the plants are in full bloom; the new branches with leaves and flowers are clipped leaving the main body and a few new branches to regenerate and distilled immediately (Wild herbs of Crete web site). While for the culinary purposes the pink savory can be harvested fresh just before flowering; that is because when the flowers bloom it decreases the content and quality of essential oils in the leaves (Table web site). Also, Shiffler (2019) mentioned that if the savory plants are harvested for drying, the leaves of the plants are harvested before the flowerbuds bloom.

Part III: Postharvest handling

The pink savory can be marketed in dry form which has a long shelf life, without expensive storage requirement. So, the herb after harvest can be spread to dry.

Part IV: Utilization

The leaves and stems can be used at culinary purposes; fresh or dry. The leaves are antibacterial, aromatic, digestive, expectorant and tonic; they are used internally to treat minor digestive discomfort and bronchial congestion. The essential oil obtained from the plant, contains thymol and carvacrol, with the thymol content reaching the 19% (Practical plants website). In addition, the leaves have a thyme-like flavor; the leaves and young shoots are used as a tea substitute (PFAF).

3.6 Tropical Fruits

3.6.1 Ananas comosus L. (pineapple)

Part I: General aspects

Classification:

Scientific name: *Ananas comosus*

Common names: pineapple, ananas

Family: Bromeliaceae

Figure 3.48 General morphology of the pineapple

Origin and distribution:

The pineapple (see also Figure 3.48) is widely distributed in the Americas (Orinoco, Amazon, coastal Brazil around Rio de Janeiro) and the Caribbean prior to the arrival of Columbus (Rohrbach et al., 2003)

Production levels:

The world fruit production of pineapple is 27.9 million tonnes, and average yield is 25.12 tonnes/hectar. The top production countries are Costa Rica, Philippines, Brazil, Thailand, Indonesia, India and Nigeria. Europe is the largest continent in raspberries production (FAOSTAT, 2018). In Africa, pineapples are produced in Angola, Tanzania and South Africa with production less than 100 000 tonnes per year (Louw, 2020).

Description of the Plant:

The pineapple is a herbaceous perennial of the Liliopsidae (monocotyledonous), whose terminal inflorescence gives origin to a multiple fruit (sorose). The plant reaches 0.75-1.5 m height and 0.9-1.2 m in width. The leaves may be all green or variously striped with red, yellow or ivory down the middle or near the margins. The leaf number is variable between cultivars but generally around 40-80 per plant. At bloom stage, the stem begins to elongate and enlarge near the apex and puts forth a head of small purple or red flowers, each accompanied by a single red, yellowish or green bract. The inflorescence develops from the apical meristem (d'Eeckenbrugge and leal, 2003).

Climatic requirements:

Concerning the temperature, the pineapple needs an average temperature of 25-32 ºC for growth, while the precipitation rate can vary between 1,000-1,500 mm. The humidity needed is high, although pineapple tolerates relatively long periods of drought. Moreover, when pineapple is planted in lack of water conditions at the beginning of flowering and fruit set, the plant growth and the fruit size is decreased (Malézieux et al., 2003). Pineapple plants also need high light intensity to enhance the plant growth, the coloration of the shell and the quality of the fruit (Malézieux et al., 2003).

Soil requirements:

The pineapple plant prefers fertile, well-drained soil and soil that contain enough quantity of humus and elements of mineral nutrition. One of the soil factors limiting pineapple growth is the low permeability mainly in rainy climates, as it promotes the attack of pathogens in the root system. It tolerates a wide range of soil pH and texture, but slightly acidic or neutral pH soils (4.5-6.5) are preferable higher pH increases the risk of microelements deficiencies.

Part II: Cultivation practices

Propagation:

Various vegetative materials can be used to propagate pineapple plants. These plant materials are crowns from the top of the fruit, slips from the peduncle directly below the fruit, suckers grown from the plant for a few to several weeks after fruit is harvested. In addition, the tissue culture technique that can be used in order to propagate pineapple (Hepton, 2003).

Soil preparation:

Site selection is very important, it is better to cultivate it at well drained soils. In addition, rock removal is necessary if its diameter is greater than 30 cm. Soil tillage improves the soil conditions and is important to maintain relatively smooth, level ground for orchard work and harvesting. Organic matter can be added to the soil in order to improve the soil properties enhancing the growth of the plants in poor soils. After the basic tillage operation takes place, raising the planting beds may be performed.

Planting:

The planting density varies from 29,000 to 86,000 plants/ha as affected by solar radiation and nutrition. Plants can be arranged in the field in single rows or in beds of two, three or four rows. The spacing between plants in the row and between rows is determined by the desired plant population density, type of planting material, planting methods (Hepton, 2003).

Fertilization:

Pineapple has high requirements for fertilizer N, potas sium (K), and iron (Fe), and relatively low requirements for fertilizer phosphorus (P) and calcium (Ca). The fertilization rates are 450 kg/ha N (400–500 kg/ha is common), 400 kg/ha K, 25 kg/ha magnesium (Mg), and 2 kg/ha zinc (Zn). In addition, foliar spraying of iron and microelements can be performed on the plants (Hepton, 2003).

Irrigation:

The pineapple plant is a xerophyte and is capable of good crop production under relatively low water regimes, the plant responds well to as much as 5 cm (ca. 2 inches) of water per month from rain or irrigation (Hepton, 2003).

Disease control:

The pineapple is affected by many diseases and pests. Fusarium stem rot is caused by *Fusarium subglutinans*. The disease is associated with the fruit-rot phase termed (Fusariosis) which first infects the developing fruit and then the suckers and slips. Roots rots may be caused by *Phytophthora cinnamomi* and various Pythium species and thesymptoms are reduction of growth, with subsequent reddening of the leaves, the leaf margins turning yellow and eventually becoming necrotic. Moreover, pineapple can be infected by bacterial and fungal heart rots caused by *Phytophthora nicotianae*. The fungal diseases can be managed by improving soil drainage, raised beds 25 cm and enhancement of the soil drainage (Rohrbach and Johnson, 2003).

Other cultivation practices:

The pineapple fruit quality is determined according to some characteristics and features of the fruits. These characteristics are appearance (size, shape), colour of the fruit (the shell and flesh colour), taste (T.S.S. and acids), aroma texture and fiber content. The fruit should be harvested at the optimum stage of maturity to obtain high quality products. Also, the fruit should be sufficiently ripened in the field to endow the flesh with high pigmentation and full pineapple flavour, but not so ripe that the fruit cannot be successfully transported and handled through the processing system. The pineapple is harvested manually, in the morning and protected from the sun. The fruit is placed in the bin crown down by hand to avoid injury. The fruit bruising is a major problem of harvesting and packaging of pineapple fruits, at the bruised area a leakage of cell contents occurred that lead to provide openings for saprophytes and disease organisms (Paull and Chen, 2003).

Part III: Post-harvest handling

After the harvesting of the fruits, they are transported to the packing house. The fruits are washed and sorted according to the size and colour. Then the fruits are treated by wax / fungicide mixes only on the fruit not the crown of the fruit (Paull and Chen, 2003).

Part IV: Utilization

The fruits have high nutritional value, as they contain vitamins C, A, B6, E and K, minerals like calcium, iron, manganese, potassium, phosphorus and zinc. Moreover, the pineapple contains bromelain that may lower inflammation. Also, it has antioxidant substances and dietary fibers (WebMD, electronic site).

3.6.2 Carica papaya L. (papaya)

Part I: General aspects

Classification:

Scientific name: *Carica papaya L.*

Common names: papaya

Family: Caricaceae – papaya family

Figure 3.49 General morphology of the papaya tree

Origin and distribution:

The Papaya (see also Figure 3.49) origin is in the tropics of the Americas (Morton, 1987). Paull and Duarte (2011) mentioned that isozyme and AFLP analysis were conducted on papaya to prove its origin and the results revealed that the greatest diversity in C. papaya exists in the Yucatan–San Ignacio–Peter–Rio Montague area of Central America.

Production levels:

The world fruit production of papaya is 13.29 million tonnes, and the average yield is 13.08 t/ha. The top production countries are India, Brazil, Mexico, Dominican Republic, Indonesia, Nigeria and Democratic Republic of the Congo. Asia is the largest continent in papaya production (FAOSTAT, 2018). In Africa, papaya is produced in Nigeria, Democratic Republic of the Congo, Mali, Ethiopia, Kenya, Malawi, Mozambique, Côte d'Ivoire and South Africa with production of about 1.441 million tonnes (FAOSTAT, 2018).

Description of the Plant:

The papaya plant erroneously referred to it as a tree is a large herbaceous plant that reaches 6 to 9 m height with a hollow stem with 30-40 cm thick at the base. The leaves emerge directly from the upper part of the stem in a spiral on nearly horizontal petioles; it reaches 30-105 cm long, hollow, succulent, green to dark purple. Both the stem and leaves contain copious white milky latex. The papaya is a dioecious plant, so it is a cross pollinated plant. Also, it may even be monoecious plants having both male and female flowers. Papaya fruit is a large berry fruit that reaches 15-45 cm long and 10-30 cm in diameter (Morton, 1987; Paull and Duarte, 2011).

Climatic requirements:

The optimum temperature for papaya growth is between 21 and 33°C and if the night temperature decreased to 12-14°C the growth and productivity are affected negatively Fruit size is determined in the first 4–6 weeks of fruit development, and temperature plays an important role in this process, especially in subtropical areas. Fruits that develop in the cooler season have lower total soluble solids and final fruit size. A monthly precipitation rate more than 100 mm with a minimum relative humidity of 66% are desirable for the growth of papaya plant (Paull and Duarte, 2011). Also, it is very sensitive to frost, strong winds and water stagnation.

Soil requirements:

The papaya plant needs well-drained soil, so the porous loam or sandy loam soil are preferred. pH should be between 5.0 and 7.0, the desirable range with the range between 5.5 and 6.5 (Paull and Duarte, 2011).

Part II: Cultivation practices

Propagation:

In commercial cultivation, seeds are used which usually germinate after 2 weeks and transplanted after forming 8-12 leaf (after 6 weeks). To cultivate a hectar, 100 g of seeds is required to produce about 2000 plants. Papaya seed can be harvested when the fruits reach ‘colour break’ stage. Moreover, vegetative propagation method can be used like cuttings. The large, leafy, lateral shoots that developed after winter can be initially used as cuttings for rooting under intermittent mist (Paull and Duarte, 2011).

Soil preparation:

Site selection is very important, as it is preferable to cultivate it at well drained soils. Soil tillage improves the soil conditions and isimportant to maintain relatively smooth, level ground for orchard work and harvesting. Organic matter can be added to the soil in order to improve the soil properties.

After the basic tillage operation takes place Discing, levelling and furrowing, Subsoiling is implemented to provide better drainage. Raised beds are used if there is a chance of flooding (Paull and Duarte, 2011).

Planting:

Concerning cultivating spacing distance, the distance varied according to the cultivation system. the single-row system, with between plant spacing ranging from 1.8 to 3 m and between row spacing varying from 1.8 m to as much as 3.6 m. The most frequently used spacing is 2.0–2.5 x 2.5 m, giving a density of 1,600–2,000 plants/ha (Paull and Duarte, 2011).

Fertilization:

Papaya plant needs heavy doses of manures and fertilizers. Manure is applied with rate of 10 kg per grown plant in the pits, 200-250 g each of N, P_2O_5 and K_2O are recommended for getting high yield. Application of 200 g N is optimum for fruit yield however, papain content increases by increasing nitrogen up to 300 g. In addition, Papaya is sensitive to boron deficiency, especially when cultivated on sandy soil/ha (Paull and Duarte, 2011) so micro-nutrients is important; ZnSO4 (0.5%) and H_2BO_3 (0.1%) are applied as foliar sprayings in order to increase growth and yield characters (Niir, 2005).

Irrigation:

In Hawaii, there are fields that not irrigated and only depend on the rainfall that is about 2,500-3,125 mm. Monthly minimum rainfall of 100 mm is needed without supplementary irrigation for some production. Irrigation may be by flooding between the row space by furrows running along both sides of the rows of trees or via micro-sprinklers or jets or drip irrigation systems. Irrigation intervals of around 10-15 days may be necessary to sustain production (Paull and Duarte, 2011).

Disease control:

Papaya is infected by Phytophthora, which cause collar and root rot, stem canker and fruit rot. Also, the seedlings are infected by Phytophthora and Pythium, which cause the damping off. In addition, bunchy or malformed top is a disease of papaya that have symptoms like appearance of new flushes of leaves that are malformed, with leaf spots and it was transmitted by leafhoppers (Paull and Duarte, 2011). Enhancing the soil drainage help in management and controlling the fungal diseases that infect the papaya plants.

Other cultivation practices:

The papaya fruits are harvested manually by hand. The harvested fruits are collected in a bucket, tray or cloth picking bag. The degree of ripeness for harvesting depends upon distance to markets. Fruits may be one-quarter to one-half ripe for local markets. While for the exportation or transportation for long distances the fruits are harvested at colour break to one quarter ripe, depending upon the cultivar’s ripening characteristics and season (Paull and Duarte, 2011).

Part III: Post-harvest handling

After the harvesting of the fruits, it can be stored at 29°C and high atmospheric humidity for 48 hours to enhance coloring before packaging (Morton, 1987).

A fungicide–wax combination is recommended prior to packaging. Incidence of storage diseases can be reduced by field spraying and proper care in harvesting and handling to avoid wounding and bruising. Skin injury is a major problem and is caused mostly by impact and abrasion during harvesting. The optimum temperature for fruit ripening is from 22.5°C to 27.5°C, with fruit taking 10-16 days to reach full skin yellowing from the colour-break stage (Paull and Duarte, 2011).

According to the papaya fruit size the fruits are graded as follows: small 284-369 g, medium 369-454 g, large 454-907 g and extra-large over 907 g. At packaging in boxes or carton, a major problem with the standard is the difficulty in achieving same size and skin colour that will ripen together in the carton (Paull and Duarte, 2011).

The post-harvest treatments used as a safeguard against diseases and pest infections such as chemical treatments like fumigation with volatile chemical and physical methods of treatments like Double Hot Water Dip and Gamma Irradiation. The double hot water dip treatment is a method in which the fruits are treated at less than quarter-ripe for an initial immersion for 30 minutes (42°C) water followed immediately by a second hot water immersion at (49°C) for 20 minutes.

Part IV: Utilization

Papayas are consumed fresh as breakfast fruit, dessert or in salads. In Asia, green fruits are cooked as a vegetable or made into preserves. The fruits have high nutritional value; it contains vitamins C, A, B6, E and K, and high mineral content of calcium and potassium. Moreover, the papaya contains papain, which is an enzyme that helps digestion and is used to tenderize meat. In addition, it is used to manufacture digestive medicine in the pharmaceutical industry (WebMD electronic site).

3.6.3 *Curcuma longa* L. (common turmeric)

Part I: General aspects

Classification:

Scientific name: *Curcuma longa L.*

Common names: curcuma, turmeric

Family: Zingiberaceae – ginger family

Figure 3.50 General morphology of the curcuma leaves

Origin and distribution:

Turmeric (see also Figure 3.50) is an aromatic medicinal plant, the cultivation of which began in India, where it was used mainly as a spice (almost 4,000 years ago). Its distribution started from India to countries in Southeast Asia and to pacific islands where it is still cultivated.

Production levels:

Globally, India has the highest production, consumption and export of turmeric. It is followed by Thailand, other countries of Southeast Asia, Central and Latin America and finally Taiwan. On an annual basis, about 11 million tonnes of turmeric are produced worldwide. More specifically, 78% of this production corresponds to India, 8% to China, 4% Myanamr and 6% both to Nigeria and the Bangala Desh.

Description of the plant

Turmeric usually does not grow more than 1 m in height, while its foliage is long with long stems (leaf stems).

Climatic requirements:

Turmeric grows in different conditions, for example it can be grown from sea level at 1,500 meters in the hills, in a temperature range of 20-30°C with a rainfall of 1,500-2,250 mm per year.

Soil requirements

Turmeric can be grown in a variety of soils, but grows best in well-drained sandy or clayey loam rich in humus (https://www.indiaagronet.com/indiaagronet/crop%20info/turmeric.htm#8).

Part II: Cultivation Practices

Propagation

Turmeric is propagated by root or rhizome cuttings and can be grown both indoors and outdoors. It grows at relatively high temperatures 20°C to 30°C, while a sufficient amount of water is required for its growth. However, it is also grown in colder climates, but during the summer (https://www.indiaagronet.com/indiaagronet/crop%20info/turmeric.htm#8).

Soil preparation

During the preparation of the land for the cultivation of turmeric, the beds should be prepared with a height of 15 cm and a width of 1 m. It is worth noting that during the sowing should be allowed over 10 cm between the rhizomes, while the beds should be spaced 50 cm (https://www.indiaagronet.com/indiaagronet/crop%20info/turmeric.htm#8).

Fetilization

In the case of organic farming, it is necessary to regularly observe the field, while in the case of non-organic farming, manure should be applied. More specifically, when sowing turmeric, a mixture of potassium and phosphorus should be applied, while after 120 days of planting, nitrogen should be added (https://www.indiaagronet.com/indiaagronet/crop%20info/turmeric.htm#8).

Irrigation

Irrigation of turmeric depends on the type of soil; irrigated crops require 15-20 irrigations in heavy soils and 35-40 in light soils. It is worth noting that plant growth can be significantly affected by moisture stress, especially during rhizome swelling (https://www.indiaagronet.com/indiaagronet/crop%20info/turmeric.htm#8).

Disease control

During the cultivation of turmeric, various diseases have been recorded, among which bacterial and viral do not have significant effects on plant growth. However, rhizome rot, leaf spot and leaf blotch diseases are the most important (Nageshwar Rao, 1995).

Part III: Post-harvest handling

After harvesting the turmeric is washed so as to remove soil that is attached to it. Then, the washed rhizomes should be dried immediately, so that there is no possibility of infection. This process significantly reduces the possibility of microbial load on the turmeric rhizome. However, if mechanical drying is applied the possibility of contamination is significantly reduced. The dried rhizomes should then be sieved to remove excess materials (FAO, 2014). However, according to FAO (2014), after processing and drying, turmeric should be disinfected as its microbial load has probably not been completely removed. Finally, during the storage, turmeric rhizomes and powder should be kept away from light and in a very dry environment.

Part IV: Utilization

Turmeric is well known for its applications in cooking, medicines and cosmetics. More specifically, it is a famous spice in South Asia and the Middle East. In addition, it is very often applied as a coloring agent in various foods such as cheese and butter, due to the yellow color it gives to them (Prasad and Aggarwal, 2011).

3.6.4 Musa acuminata Colla (edible banana)

Part I: General aspects

Classification:

cientific name: *Musa acuminate*

Common names: banana

Family: Musaceae – banana family

Figure 3.51 General morphology of the banana tree

Origin and distribution:

The bananas and plantains (see also Figure 3.51) origins are South-east Asian and western Pacific regions where their ancestors (inedible, seed-bearing, diploid) can still be found in the natural forest vegetation (Robinson and Saúco, 2010).

Production levels:

The world fruit production of bananas is 115.73 million tonnes, and the average yield is 20.20 t/ha. The top production countries are India, China, Indonesia, Brazil, Ecuador, Philippines, Guatemala and Colombia. Asia is the largest continent in bananas production (FAOSTAT, 2018).

In Africa, Bananas are produced in Angola, United Republic of Tanzania, Kenya, Cameroon, Mozambique, Egypt, Democratic Republic of the Congo, South Africa Mali, Ethiopia, Kenya, Malawi, Côte d'Ivoire, and South Africa with production about 1.441 million tonnes (FAOSTAT, 2018).

Description of the Plant:

The banana is a perennial herbaceous plant which erroneously referred to it as a tree. The plant trunk (Pseudostem) consists of tightly packed layers of leaf sheaths that emerge from rhizome, the true stem of the banana plant grows underground as a tuberous rhizome. The rhizome has extremely short internodes covered externally by closely packed leaf scars and is an important storage organ for sustaining growth of the bunch and the developing sucker. The suckers grow successively outwards and there is a small amount of horizontal growth before the sucker turns upwards. The leaves produced at first are scale leaves that produced from the central meristem of a developing sucker, followed by narrow sword leaves, and finally broader leaves. The apical growing point at the base of the pseudostem stop producing young leaves and starts to form an inflorescence. The developing flower stalk or peduncle extends within the pseudostem until it forces the inflorescence out through the top (neck) of the plant, the neck being formed by the petioles of the last few leaves to emerge (Robinson and Saúco, 2010).

Climatic requirements:

Geographically, the banana growing areas are situated between the Equator and latitudes 20°N and 20°S, as at these areas the climatic conditions are tropical, with small temperature fluctuations from day to night and from summer to winter. While at the subtropics banana growing areas of between 20° and 30° north or south of the Equator, the climatic conditions characterized by high temperature fluctuations from day to night and from summer to winter, and low annual precipitations (Robinson and Saúco, 2010).

The optimum mean temperature for growth and productivity is about 27°C, while the maximum temperature for growth is 34°C, as at 38°C the plant stops growing and heat stress occurred. The minimum growth temperature is 14°C, as dropping to 6°C leads to leaf chlorophyll destruction and leaf yellowing so the plant is stressed.

Regard to water requirements, the banana plant needs annual precipitations about 2,000–2,500 mm, so at subtropics growing areas additional irrigation is needed (Robinson and Saúco, 2010).

Soil requirements:

The banana plant needs deep, well-drained loams with high fertility and organic matter content. The preferable soil pH is between 5.8 and 6.5. Also, saline soil conditions are not desirable (Robinson and Saúco, 2010).

Part II: Cultivation practices

Propagation:

The banana plant is propagated by suckers and bits. The sucker is a detached rhizome in which the central growing point forms the new plant while all axillary buds are removed. In commercial cultivations, in vitro plantlets are used which are produced via micro-propagation (tissue culture) technique of a sucker (Robinson and Saúco, 2010).

Soil preparation:

Site selection is very important especially at subtropics areas, where long-term temperature data should be considered. It is better to cultivate it at well-drained soils. It is preferred to select a site with high fertile soil; otherwise, organic matter must be added. Soil tillage improves the soil conditions andit is important to maintain relatively smooth, level ground for orchard work and harvesting (Robinson and Saúco, 2010).

Planting:

Concerning cultivating spacing distance and the planting density, the distance varied according to the cultivation system. As standard the planting density is about 1666 plant/ha. Commonly, there are three cultivation systems which are rectangular (3 x 2 m), hedgerow (4 x 1.5 m) and tramline (6 x 2 x 1.5 m), also the best spacing distance is the rectangular since it gives the highest productivity compared to the other cultivation systems. Moreover, new and modern planting system and spacing distances are used such as in Canary Islands where it was cultivated with wide interrows with planting density 2,000-2,400 plants/ha (Robinson and Saúco, 2010).

Fertilization:

In order to calculate the nutrient quantities that the plants need, soil and leaf analysis should be performed (Lahav, 1995). Nitrogen ranges from 3.3 to 3.7%, phosphorus greater than 0.14%, potassium 4.5 to 5%, calcium 0.8 to 1.3% and magnesium 0.3 to 0.4%. The fertilization requirements differ according to the soil analysis. The fertilization recommendation rates are 190-359 kg N, 91-146 P_2O_5, 454-988 K_2O, 67-121 CaO, 76- 139 MgO (Rodríguez et al., 2007).

Irrigation:

The banana plant is sensitive to both a shortage and an excess of water. Regard to water requirements, the banana plant needs annual precipitations about 2,000-2,500 mm. In subtropics growing areas additional irrigation is needed (Robinson and Saúco, 2010). Drip irrigation can be used in order to provide the plants with its water requirements especially at subtropics site.

Disease control:

Bananas may be susceptible to many diseases. One of the most serious diseases that threat banana cultivations is black leaf streak (*Mycosphaerella fijiensis*), commonly called (Black Sigatoka) which is a fungal disease. Its'symptoms are on leaves that become small, translucent, pale yellow streaks which develop into black. Also, it causes destruction for the banana grown at tropical areas. It can be controlled by spraying fungicides mixed with oil on the foliage of the plants, by a dosage of 10–60 sprays/yeardepending on the climatic conditions. Moreover, banana is infected by Panama wilt disease caused by (*Fusarium oxysporum* f. sp. *cubense*), when the fungus penetrates through wound tissue, and spreads through the xylem system into the rhizome and pseudostem, its symptom is thatthe older leaves begin to turn yellow prematurely. Yellowing begins along leaf margins and advances towards the midrib. It can be controlled by fumigation and the use of in vitro plantlets which are disease free. In addition, there are other diseases that infect the banana plantaion such as moko disease, banana bunchy top disease and banana streak disease (Robinson and Saúco, 2010).

Other cultivation practices:

The banana fruit continues to develop attached to the plant accumulating starch in the pulp. The finger length continues increasing until about 80-90 days after flowering (in the tropics) when fruit maturation begins. At this time, fingers stop elongating, but they continue to increase in width until the fruit is harvested. Many methods such as coloured ribbons and calliper measurement of finger diameter are used in order to indicate the harvest stage of the banana fruits. The green life is a term that defines the period between harvesting and the visible stage. The green life differs according to the marketing; fruit could be harvested fully mature for immediate ripening and local marketing. While for short-distance transport of green fruit, 90% of full maturity could be used, and for medium-distance transport by truck, 75% maturity is used (Robinson and Saúco, 2010).

Part III: Post-harvest handling

The harvested banana fruits pass through four physiological development stages, which are the green life stage, the climacteric stage, the ripening stage and finally the eat-ripe and senescence stage. In order to prolong the green life stage, the harvest takes place at early stage of maturity, bunches are transported at 13°C and the fruits are stored at controlled atmosphere. Kader (2001; 2002) showed that the combination of 12-16°C, 2-5% O and 2-5% CO_2 delay the ripening of the fruits. At the climacteric stage the fruits produce ethylene by increasing the respiration rate. Mature banana fruits can ripe naturally will eventually soften, but the peel may sometimes become dull, pale yellow and unattractive. So artificial ripening can occur by increasing the temperature and applying ethylene gas at 1000 ppm.

Part IV: Utilization

Bananas fruits are consumed for its mineral and antioxidant contents. The fruits contain Vitamins C and B6, potassium, magnesium, manganese, and copper. In addition, they have fibers that improve the human digestion health. Moreover, the fruits contain pectin that moderate blood sugar levels. Furthermore, the potassium and antioxidants (dopamine and catechins) contents are essential for the heart health since potassium control the blood pressure and kidney health, while these antioxidants reduced risk of heart disease and degenerative illnesses (WebMD electronic site). Also, bananas considered to be used at the diet regimes and from athletes as a powerful food that provides sugars and minerals to their bodies, reducing also exercise-related muscle cramps and soreness.

3.6.5 *Panax ginseng* C. A. Meyer (ginseng)

Part I: General aspects

Classification:

Scientific name: *Panax ginseng*

Common names: Asian, Chinese or Korean ginseng

Family: Araliaceae – ginseng family

Figure 3.52 General morphology of the Korean ginseng flower

Origin and distribution:

The Asian ginseng (see also Figure 3.52) is native to mountainous regions of Russian Far East, North-eastern China, and the Korean Peninsula (USDA, 2019b).

Production levels:

Baegand Ho So (2013) mentioned that the world production of ginseng was 80,080 tonnes based on ginseng statistical data of Korea ministry of food, agriculture, forestry and fishers for 2010.The top production countries are China that produce more than 55% of the world production, South Korea, Canada and USA (Li, 1995; Baegand Ho So, 2013).

Description of the Plant:

Ginseng is an herbaceous perennial that is cultivated for roots thatare highly valued (Proctor and Bailey, 1987). The Asian ginseng can be divided to two types based on the shape of the rhizome (Round and long). The round rhizomes are short, thick and white with shorter main roots with many side branches and the plant grows rapidly with high root yield, while the long rhizomes are long, thin with creamy yellow short main roots and the side branches are less than the round rhizome type. The long rhizome type doesn't produce seeds until the 4th year, while the round rhizome type produces seeds in the 3rd year. The leaf margin is serrated (Li, 1995). Ginsend is a slow-growing, perennial plant, and the roots are usually harvested when the plants are five or six years old (Mahady et al., 2001). Then, the roots are submitted to air drying (white ginseng) or are steamed (red ginseng) (Mishra and Verma, 2017).

Climatic requirements:

The ginseng requires 70-90% natural or artificial shade. The optimum mean temperature for growth and productivity is about 10°C, but in dormancy period the plants need further decrease of the temperature for several weeks (Harrison et al., 1992). In addition, Yang (1974) revealed that the optimum air temperature needed for growing of Asian ginseng is 16-18°C.

Soil requirements:

The Ginseng generally prefers well drained a loamy, deep soil, with a high organic content and soil pH near 5.5. Moreover, if the soil is too sandy, the plants tend to produce long, slender small branches of roots of inferior quality called cow tail's (Li, 1995). Heavy clays and very sandy soils are poor for ginseng (Harrison et al., 1992).

Part II: Cultivation practices

Propagation:

Seeds are used in order to propagate ginseng plants and theyneed to be cold stratified for 18-22 months to break the dormancy of the seeds. The seeds are planted at rate of 750 per m^2 and then transplanted after a year later (Li, 1995). In addition, ginseng needs 3-5 years to produce a marketable crop from seed (Harrison et al., 1992).

Soil preparation:

Site selection is very important, as well drained soils are preferable. Soil tillage improves the soil conditions and is important to maintain relatively smooth, level ground and the tillage depth is about 25-30 cm. Also, rocks should be removed before planting (Harrison et al., 1992).

Planting:

Concerning cultivating, the ginseng seeds are commonly planted in the fall and covered with mulch (5-7.5 cm of straw) until spring in order to keep the seeds from drying out. The seeds are sown in rows 10 cm between the seeds on the same row and about 15 cm between rows on the bed important (Harrison et al., 1992).The seeds are planted at rate 750 per m^2 and then transplanted after a year later (Li, 1995). The transplants are cultivated with spacing distance about 20 cm in each direction (Harrison et al., 1992).

Fertilization:

In order to calculate the nutrient quantities that the plants need, soil and leaf analysis should be performed. The heavy fertilization with organic (manure) and chemical fertilization decreases the similarity between the wild ginseng roots and the cultivated ginseng, so it may decrease its marketability (Harrison et al., 1992).

The fertilization rates recommendations are to use about 22.5-67.5 kg N, 17 kg P_2O_5 and 67 kg K_2O/ha (Harrison et al., 1992). While Li (1995) mentioned that in Korea and Japan, the fertilizers rates used were 28.5 kg N, 6.7 kg P_2O_5 and 31.5 kg K_2O/ha. Also, applying micronutrients is suggested.

Irrigation:

Regard to water requirements, the ginseng plant needs annual precipitations about 1,000-1,270 mm (Harrison et al., 1992). Drip irrigation can be used to supply plants with additional irrigation.

Disease control:

Ginseng plant is susceptible for many fungal and bacterial diseases. The plant grown naturally in woods is more tolerant to many diseases than the artificial shaded ones. The fungal diseases include Alternaria leaf and stem blight, Phytophthora root rot and foliar blight, Pythium and Rhizoctonia caused seedling damping-off, rusty root. To control and minimize the plants infections with these diseases and pathogens, cultivating at well drained soils and the good air circulation is very crucial in order to reduce the relative humidity surrounding the plants (Li, 1995).

Other cultivation practices:

Shading: The ginseng plants thrive when grow at shady conditions. Naturally, it grows under impermeable straw; also, at seedlings production in the nurseries it is recommended to shade the plants. Artificial shade is provided to the plants using polypropylene fabric or wooden lath sheds, placed about 2.25 m above the plants to enhance the air circulation (Harrison et al., 1992).

Flower thinning: The flower thinning revealed an increase in the root yield of ginseng plants. Also, the removal of all flowers increases yield by about 50 % (Li, 1995).

After 6 years of cultivation of Asian ginseng, the roots are harvested. The roots are 7-13 cm long, 2-5 in (ca. 5-13 cm) diameter and the fresh weight of the roots 40-80 g.

Part III: Post-harvest handling

The roots of ginseng are washed after harvesting to remove the attached soil on the surface of the roots. It is necessary to handle the roots carefully to keep the branching forks intact and maintain the natural color and circular markings (Harrison et al., 1992). After harvesting the roots, they are washed and graded according to size in three categories (roots more than 20 cm, 10-20 cm and less than 10 cm long). In order to apply the drying process for ginseng roots, as setting the temperature of drying is based on the size of the roots. The ideal root moisture content is 8%. It is suggested that the roots are dried at 38°C in order to avoid root browning (Li, 1995).

Part IV: Utilization

Ginseng roots have been used as a medical plant. It contains ginsenosides which consists of triterpene glycosides, orsaponins. Also, many active compounds can be found in all parts of the plant, including amino acids, alkaloids, phenols, proteins, polypeptides, and vitamins B 1, 2 and 3 (Mishra and Verma, 2017). Also, Asian ginseng roots are used by diabetes patients for its beneficial use in blood sugar regulation (Sotaniemi et al., 1995). Many studies were conducted to investigate the effect of ginseng on cancer prevention that revealed an anti-inflammatory role of Asian ginseng in the sequence of progression to promotion in a model of carcinogenesis (Volate et al., 2005).

Asian ginseng is consumed by mouth to improve thinking, concentration, memory, Alzheimer's disease, work efficiency, physical stamina, preventing muscle damage from exercise, and athletic endurance. Also, it helps to overcome the stress and is used as a general tonic for improving well-being (Web MD) electronic site.

3.6.6 *Passiflora edulis* Sims (passion fruit)

Part I: General aspects


Classification:

Scientific name: *Passiflora edulis*

Common names: purple passion fruit, purple granadilla

Family: Passifloraceae – Passion-flower family

Figure 3.53 General morphology of passion fruit

Origin and distribution:

The purple passion fruit (see also Figure 3.53) is considered native to southern Brazil, and it is widely distributed in South America countries, the Caribbean and into Asia, Africa, and Australia (Paull and Duarte, 2012).

Production levels:

Morton (1987) mentioned that the yield of passion fruit is about 20-35 t/ha (for yellow passion fruit). Thokchom and Manda (2017) stated that the total production of passion fruit in India was 129,270 tonnes. The economic yield starts after 1-2 year of planting and a healthy plant produces about 150-180 fruits/year and the average yield of fruits is 5-6 t/ha (Purple passion fruit).

Description of the Plant:

There are two recognized types of edible passion fruit; purple (*Passiflora edulis* Sims) and yellow (*Passiflora edulis* Sims *f. Flavicarpa* Deg.) and the latest consider to be a mutation of the purple passion fruit. The passion fruit plant is perennial vine with medium to large, serrated leaves. The purple passion fruit plant has green tendrils. The vine reaches up to 10 m long. The flower is about 7.5-10 cm in diameter and consists of five sepals and five white petals. The flower buds are produced at every node of new growth. The flower is cross pollinated by insects, the fruit set is about 70% by natural pollination and it reaches 100% by hand pollination. The purple fruit is about 3.5–7 cm in diameter and 4-9 cm in height, with a weight of 60-100 g (Paull and Duarte, 2012).

Climatic requirements:

The purple passion fruit is subtropical, and it is more adapted to areas with cool period. The well distributed annual precipitations are necessary for passion fruit production; however, precipitation must be minimal during the blooming so that the pollen grains are not be exposed to wetting. The purple passion fruit grows well at altitudes of 650-1,300 m. The optimum precipitations range between 800-1,750 mm for the yellow passion fruit. Moreover, in Australia, the purple passion fruit needs 300-400 l/vine/week is required during the summer (Paull and Duarte, 2012).

Low temperatures of 15°C at day and -10°C night reduce vegetative growth and potential yield, while high temperatures 30-25°C can prevent flower production. The optimum temperature for growth and productivity for purple passion fruit are temperatures 4.5-13°C at night and 18–30°C at day. The mature vines can withstand light frost but are highly affectedat -1 to -2°C (Paull and Duarte, 2012).

Soil requirements:

Passion fruit can tolerate and grow in a wide range of soil types; however, the plant is highly susceptible to poor drainage and waterlogging. The preferable soil pH may range from 5.5 to 6.8 (Paull and Duarte, 2012).

Part II: Cultivation practices

Propagation:

The passion fruit can be propagated by seeds, cuttings, air layering, and grafting on rootstocks. Commonly, the purple it is propagated by grafting the scions on yellow passion fruit rootstocks at 50 cm above the ground level since the grafted seedlings is more vigorous and have longer lifespan (Paull and Duarte, 2012).

Soil preparation:

Site selection is very important, it is better to cultivate it at well drained soils. Soil tillage improves the soil conditions, it is important to maintain relatively smooth, level ground for orchard work and harvesting (Paull and Duarte, 2012).

Planting:

Seeds are sown in trays and after germination they grow in semi shade place for 1-2 months, then the seedlings are transplanted individually in plastic container after forming 2-4 leaves. Then they are transplanted in the field after reaching 25-50 cm tall. For the grafted vines, the scion portion should have grown until it reaches 25 cm and hardened (Paull and Duarte, 2012). The passion fruit plants are grown on trellis system. There are two commonly trellis systems which are I (vertical) and T (cross) type of trellises. The cultivation spacing for purple passion fruit or its hybrids at cooler subtropical areas is 2.5-3 m apart because of less vigorous growth (Paull and Duarte, 2012).

Fertilization:

In order to calculate the nutrient quantities that the plants need, soil and leaf analysis should be erformed. It is recommended to add 113 g of compound fertilizer 10:5:20 at planting for every vine for the first year, and to repeat this application every 6-8 weeks. For purple passion fruit and its hybrids is suggested to add compound fertilizer with grade 15:4:11 at 500 g/vine/application, and this application is repeated four times alternated with 460 g urea applications (Paull and Duarte, 2012)

Irrigation:

The passion fruit plant is herbaceous plant which good supply of water to thrive. The optimum precipitations range between 800-1,750 mm for the yellow passion fruit. Moreover, in Australia, the purple passion fruit water needs are 300-400 l/vine/week during the summer (Paull and Duarte, 2012). Drip irrigation can be used in order to supply the plants with its water requirements.

Disease control:

Passion fruit is susceptible to many diseases. The most common disease infects passion fruit at various conditions (Tropic and subtropics) and is the Alternaria brown-spot disease. Fusarium wilt cause by *Fusarium oxysporium* f. sp. *Passiflorae* leads to high losses on the purple passion fruit, and its

Symptoms are browning of the vascular system of roots, crown and stem. It can be controlled and reduced only by grafting the plant (Morton, 1987). Moreover, Phytophthora blight is serious where purple passion fruit is grown. It affects the vines, causing defoliation and rotting fruit. It is preferable to cultivate passion fruit plants at well-drained soils.

Other cultivation practices:

The passion fruit is commonly harvested manually by hand. The fruits are left to ripe of the vines and the fallen fruit are gathered once or twice per week, depending on the quantity (Paull and Duarte, 2012).

Part III: Post-harvest handling

The harvested fruits are packaged in small cardboard boxes of 5-10 kg for fresh marketing. In Australia, marketing standards for fresh fruit passion market is that the fruit is half to full ripening, not less than 35% pulp and larger than 4 cm in diameter (Paull and Duarte, 2012). Concerning storage, the fruit coating with paraffin, storage at 5-7°C and relative humidity of 85 to 90%, has prevented wrinkling and preserved quality for 30 days (Morton, 1987).

Part IV: Utilization

The purple and yellow passion fruits are rich in good sources of vitamin A, niacin, riboflavin, and ascorbic acid (Paull and Duarte, 2012). In addition, passion fruit provide the body with minerals such as calcium, magnesium, phosphorus, potassium, and folate and these help your kidneys, nerves and muscles (WebMD, electronic site).

3.6.7 Zingiber officinale Roscoe (ginger)

Part I: General aspects

Classification:

Scientific name: *Zingiber officinale*

Common names: ginger

Family: Zingiberaceae – ginger family

Figure 3.54 General morphology of the ginger plants and roots

Origin and distribution:

The ginger (see also Figure 3.54) is native to Southeast Asia. Nowadays it is cultivated and distributed at tropical regions in the Caribbean, Central and South America, Australia, Africa and Asia (Fikre and Kifle 2013; Kaufman, 2016).

Production levels:

The world production of ginger is 2,785 million tonnes. The top production countries are India, China, Nigeria, Nepal, Indonesia, Thailand, Bangladesh, and Cameroon. The average yield is about 7.5 t/ha (FAOSTAT, 2018).

Description of the Plant:

Ginger is an herbaceous perennial monocotyledonous plant that is cultivated at tropical sites and usually grown as an annual. It produces thickened and fleshy rhizomes. The stem is erect, unbranched and mainly formed by the leaf sheaths. The leaves are linear, sessile, and glabrous. The Inflorescence arises direct from rhizome, spiciform, 15-30 cm long and the flowers are yellowish green, the spikes are cylindrical, and fruits are oblong capsules (Fikre and Kifle, 2013; Kaufman, 2016).

Climatic requirements:

The ginger plant grows well at tropic sites from sea-level up to 1,500 m altitude, but mainly it is found at low latitudes. It prefers brilliant sunshine, heavy rain fall and high amount of relative humidity (Fikre and Kifle, 2013). Concerning temperature, the mean annual temperature for growth and productivity is about 20°C for the lower limit and 30°C as the higher limit (Kaufman, 2016).

Regard to water requirements, the ginger plant needs annual precipitations about 2,500-3,000 mm distributed all over the year (Kaufman, 2016; Jaidka et al., 2018).

Soil requirements:

Ginger plant is an exhaustive crop, so it is preferred that the soil fertility is high, or manure should be applied in high quantities. The adequate soils are medium loams rich with organic matter; however, ginger is very sensitive to waterlogging. Moreover, ginger is grown on a wide pH range of soils (6.0-7.0) (Kaufman, 2016; Jaidka et al., 2018).

Part II: Cultivation practices

Propagation:

In a conventional propagation, the underground rhizomes are the planting materials of ginger by portions known as seed rhizomes (Jaidka et al., 2018); however, it has a low multiplication rate. Moreover, tissue culture is used in vitro plantlets (Seran, 2013).

Soil preparation:

Site selection is very important, it is better to cultivate it at well drained soils. Soil tillage improves the soil conditions. Deep plowing is necessary to break an impermeable hard sub soil layer, remove the weeds and bring the land to fine tilth (Fikre and Kifle, 2013).

Planting:

Ginger is propagated by portions of the rhizomes. The quantity of seed rhizomes varies from 900-1,400 kg/ha. The optimum spacing for planting of ginger is 25-45 cm between rows and 15-20 cm between plants in the same row. The seed rhizome should be 20-30 g in weight with at least 2 sprouted eye buds. The sowing depth is 3.5-5.0 cm (Jaidka et al., 2018).

Fertilization:

The ginger plant is an exhaustive crop, so it is recommended to add 25-30 t/ha of manures or compost (Harrison et al., 1992). In India, the fertilization rates used are 100 kg N, 50 kg $P_2O_5$and 50 kg K_2O, while at low fertile soils 250 kg N, 100 kg P_2O_5 and 100 kg K_2O (Jaidka et al., 2018).

Irrigation:

Regard to water requirements, the ginger crop grows under irrigation conditions and is watered immediately after sowing. It needs annual precipitations about 2,500-3,000 mm distributed all over the year (Kaufman, 2016; Jaidka et al., 2018). Drip irrigation can be used to supply plants with additional irrigation.

Disease control:

Ginger plant is susceptible for many fungal and bacterial diseases. One of the most common disease infect the ginger plant is soft rot (rhizome rot) and it caused by Pythium aphanidermatum. Younger sprouts are the most susceptible to pathogen. The collar region of the pseudostem is infected at first then the infection spreads upward as well as downward. The pseudostem infected becomes water soaked and the rotting spreads to the rhizomes resulting in soft rot. The symptoms of the disease on the foliage are light yellowing of the tips of lower leaves which spreads to the leaf blades. It can be controlled by treating the seed rhizomes with suitable fungicides (Mancozeb) before storage and again before cultivation. In addition, bacterial wilt infected ginger plants caused by *Ralstonia solanacearum*, water-soaked spots appear at the collar region of the pseudo stem, its symptoms are drooping and curling of leaf margins of the lower leaves. Also, the plants are infected by Phyllosticta zingiberi, which cause the leaf spot disease that characterized by forming water-soaked spots and later turns as white spots surrounded by dark brown margins. Also, the plants are infected by root not nematode (Meloidogyne spp.) (Jaidka et al., 2018).

Other cultivation practices:

The ginger rhizomes are harvested after 7-8 months and at this time the leaves turn yellow and start drying up. The early harvested ginger gives rhizomes with less fibre content and pungency, while for drying purpose, it is better to delay the harvesting (Jaidka et al., 2018).

Part III: Post-harvest handling

After the rhizomes are collected, curing process takes place by washing with water and then dried in sun for 7-10 days. (Jaidka et al., 2018). According to the marketing, bleaching process maybe is needed as the Middle East countries that import ginger rhizomes prefer the white rhizomes which are free from specks or spots. After that, the rhizomes are graded according to their shape, size, and number of fingers, colour, and scales.

Part IV: Utilization

Ginger is widely used as a spice; also, the fresh and dried rhizomes yield an essential oil (ginger oil) and oleoresin (ginger extract). Ginger has been used infolk medicine especially for carminative, stimulant of the gastro-intestinal tract, rubefacient and counterirritant. In addition, ginger exhibits antispasmodic and anti-inflammatory activity, helps reduce cholesterol, lower blood pressure, and shrink liver tumors in test animals. In humans, rhizome powder is effective against nausea (Kaufman, 2016).

4. ETHNOBOTANICAL STUDIES IN LESVOS INCLUDING INTERVIEWS PROTOCOLS

4.1 Scope of the study and methodology

As describes in the DoA, HYDROUSA provides among others innovative, regenerative and circular solutions for (a) nutrient management, boosting the agricultural and energy profile; and (b) local economies, based on circular value chains. The services provided lead to a win-win-win situation for the economy, environment and community within the water-energy-food-employment nexus.

HYDROUSA will implement a biodiverse agroforestry system, depending on the output of the local community, where fruit trees will be used as wind protectors and shade providers, shrubs as superfood providers, and several local varieties of vegetable crops and aromatic plants as added value products. High value plants will be combined with beneficial organisms attracting other species to create resilience with diversity.

HYDRO2 will be developed adjacent to HYDRO1; (check the description of HYDRO2 in 2.1, see Demo site description in Figure 4.1) the land which will be used for HYDRO2 is agricultural land, which is adjacent to HYDRO2 and will be upgraded to an agroforestry system with a much larger diversity of trees, crops and shrubs. HYDRO2 is in total 1 ha (two fields of 0.7 ha & 0.3 ha) of agroforestry on Lesvos Island, irrigated with nutrient rich reclaimed water after treatment in UASB-CW system. In HYDRO2 part of the irrigation system shall consist of masonry channels from the local area which will be prepared with the delicate knowledge of the old profession of stone masonry.

Connections with local farmer associations and gardeners have already been established (See Table 5.2) supporting HYDROUSA with the organization of desired plants.

In the agroforestry system, HYDRO2, the concept will integrate biodiverse and resilient agroforestry ecosystems and selection of plants, which are well adopted to dry and windy conditions and have high market values. The agroforestry system will be divided in 3 main groups: (1) tall forestry like trees (e.g., laurel tree, cork tree, sweet chestnut), (2) medium-canopy small trees/bushes (e.g. goji berries, pomegranate, sea buckthorn and olive shrub), herbs (e.g. lavender, sage, oregano, thyme, mint) and annual crops. It will produce superfoods, high added value herbs, local fruits and timber. After the growth periods, the residual biomass will be shredded and used for co-composting in the closed vessel system of HYDRO1. The produced compost will be used again in the agricultural systems.

The plant setup will be co-creatively elaborated with the public for a definition of business cases and to form resilient ecosystems. Catalogue of selected plants, description, availability, and product development options is implemented within the activities of HYDROUSA.

This report gives insights to create the comprehensive catalogue of all the plants & crops which will be grown on the sites. This report is developed based a. on literature review on ethnobotanical studies and other related publications linked to Lesvos and HYDROUSA's pilot at Antissa (band with inputs of the local community through the participatory workshop (See 2.1.1 Community engagement at Antissa),and c. interviews with locals and stakeholders (See 4.6.1 Inputs from interviews).Since the soil analysis is conducted and other criteria such as the prospects of the selected plants in the market are considered, the final decision on plant selection will happen.

Our methodology consisted of the following steps: (a) create a stakeholder mapping i.e. identify interest groups, communities, organizations, university departments to be invited to the public workshop at Antissa, (b) research on ethnobotanical studies for Lesvos. This study creates an initial catalogue of suitable plants used in the past on the island and how the agricultural production has been related to the culture of Lesvos. (d) Create a questionnaire for Interviews related to agriculture and its practices (e) Identify persons with this old plant and farming knowledge and interview them, (f) organize the community-involving workshops with this knowledge and the proposed plants and technologies the consortium suggests. (g) This co-creation workshop defines the interest of the community for a part of this agroforestry system for community farming or community supported agriculture.

HYDRO2 Antissa, Lesvos		Transport of water in automatized system and irrigation of agroforestry system with nutrient-rich reclaimed water	10 m^3/d nutrient rich water in winter; 100 m^3/d nutrient rich water in summer	Involvement of > 40 people from the community for co-creation Irrigation of 1 ha of crops/trees; Production of > 10 tons of fruits, herbs, vegetables	Wastewater can be used for fertigation; no fertiliser import; product diversity; creating resilient ecosystems	LESVOS

Figure 4.1 HYDRO2 Demo site description

4.1.1 Targets and tackled problems for HYDRO2

This report aims to document the research on ethnobotanical studies for Lesvos. We are interested in documenting plants that have been cultivated in the region of Antissa the past decades. We would like to research how these plants are linked to local customs and practical uses such as plants used for clothing, medicines, foods, and other applications. We are also interested in documenting what the well adapted agricultural plans are, what the irrigation methods have been, which challenges the farmers face regarding this in the region-nowadays and past.
The report also includes the results from the co-creation workshop in Lesvos and how the local community imagines the agroforestry system of HYDRO 2 and interview protocols. Last, the report includes a list with plants to support the selection, organization and planting of the agroforestry and recommends next steps for the agroforestry design and how the community to be engaged.

4.1.1 Agricultural History of the Island

Greece's third largest island is Lesvos (1,632.8 km^2), with ca. 90,000 inhabitants and 40% of them located at Mytilene (census 2001), the capital of the island (Kizos et al., 2008). The islands of the North Aegean are considered autonomous in terms of culture and biodiversity (Axiotis et al., 2018). The last 20 years, Lesvos has reached the average in GDP per capita of Greece affected by the establishment of the University of the Aegean (Kizos and Iosifides, 2007).
Mediterranean climate prevails on the island with its mountains and atmospheric circulation patterns to create variations in climatic conditions. Spatial variations in rainfall, long hot summers and mild winters create a strongly seasonal climate. From 677 to 415 mm ranges the annual rainfall from eastern to western part respectively with 17.7°C the mean annual air temperature (Douma et al., 2016). Volcanic geologic formations characterize the island (see Figure 4.2) with the central part covered by forest, crops and olive groves habitat and the east part with olive shrubs, forest, crops and phryganic ecosystem. The west part, where HYDROUSA's pilot is covered by bare fallow, pasture and maqui.

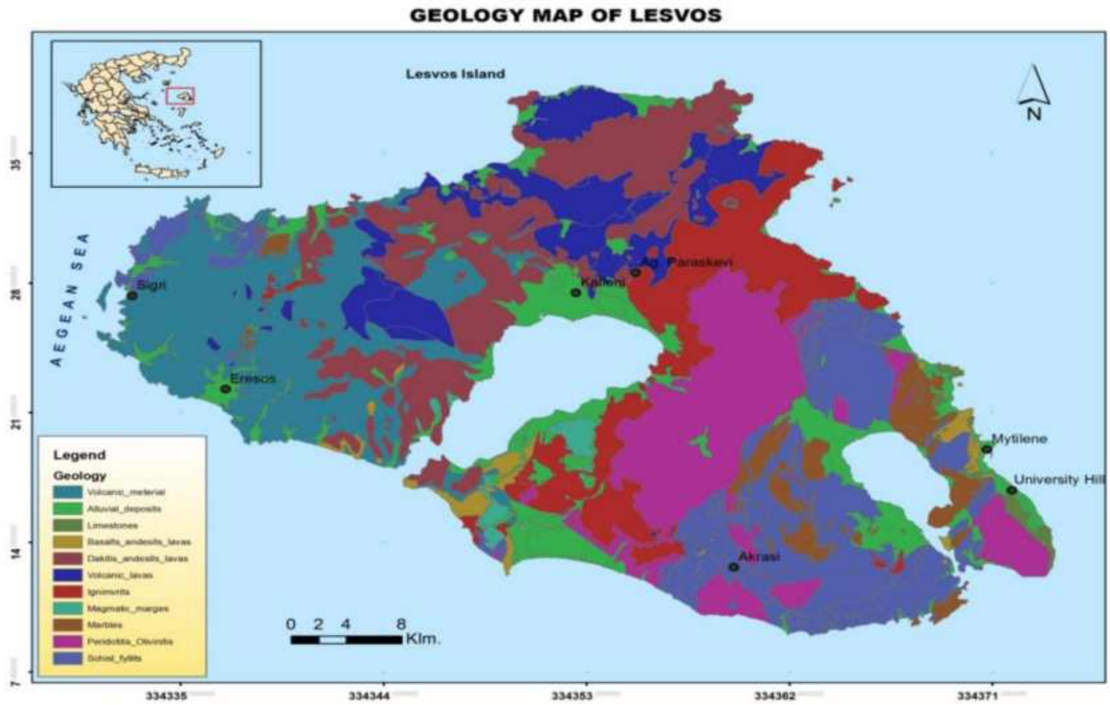


Figure 4.2 Geology map of Lesvos

Antissa is in unique location regarding the paleoflora; together with Eressos and Sigri enclose the petrified forest of Lesvos, a protected natural monument by UNESCO. Fossilized remains of plants formed the petrified forest. Different vegetation zones in the area of the petrified forest have been revealed which compose the paleoflora, which existed 20 million years ago in the region. The plants in the forest include conifers, angiosperms-flowering plants and some pteridofytes, with conifers also to include ancestral forms of sequoia and “other rare species for which there are no modern descendants” (see Figure 4.3). The research work has identified that the petrified flora was developed in a subtropical climate which was changed into a continental climate with characteristics of subtropics of Southeast Asia or America (many palm trees, types of poplar, laurel, cinnamon, plane, oak, beech, palm, alder, brier, maple and walnut) (Geopark, 2018). Phrygana (dominant species are Sarcopoterium spinosum, Centaurea spinosa, and Ballota acetabulosa) and forests of Pinus brutia, Pinus pallasiana ssp. nigra and Quercus macrolepis compose the vegetation of the area (UNESCO, 2018).

Figure 4.3 Sequoia Trunk in Lesvos Geopark (photo from Lesvos Geopark from first HYDROUSA's technical meeting in Lesvos in 2018)

On large islands, it has been commonly observed a coexistence of seaside areas with inland areas, with the agricultural and livestock farmers, due to the characteristic landscape, nature and human activities. Lesvos is perhaps a typical island case that traditionally has its inhabitants better known as oil producers and traders than "seafarers" (sailors and fishermen) (Yagku, 2003). Theophrastus, a Greek philosopher, native of Eressos, around 10 km away from Antissa, in 300 BC, in his Botanical Work "Enquiry into Plants" about Lesvos" referred to the diversity of wheat in color, size, form and their characteristic linked to productivity and nutritional value.

Theophrastus was the first who mentions the Petrified Forest in the region (Geopark, 2018).

Sapfo (630-570 BC), an Archaic Greek poet from Lesvos described that "golden spread of dwarf peas grew round the banks of rivers" (Douma et al., 2016).

Lesvos was named "Lasia" which means dense forest, because pine and oak trees densely covered the island. The agricultural history of the island began at around 1850 BC with the cultivation of olive shrubs, cereals and vineyards. The varieties of wines from the vineyard terraces of Eressos during the 4th century BC were highly esteemed. During the 3rd century BC, the landscape pattern was different from nowadays i.e., 18% of the total island area was covered with cereals and orchards, 2% with olive orchards and 3% with vineyards. Many centuries later, in Byzantine period, the olive groves, vineyards, cereal and pasture replaced the forest areas. As a result, Lesvos became self-sufficient in agricultural products. The olive zone of Lesvos was gradually expanded during the 15th Century, when wild olive shrubs in pine forests were grafted. That century, Lesvos was under Ottoman administration, which supported olive cultivation to fulfill the olive oil and soap demands in Istanbul. Sixteen products were taxed in the middle of 16th century; cereals (wheat and barley), pulses (sesame, flax, cotton), fruit and nut trees (figs, mulberries, almonds), olive, olive oi, must and wine. (Douma et al., 2016).

Cereals, fruits and wine of Lesvos Island, during the 16th century, were considered the best of the Aegean islands. European travelers on Lesvos during 17th and 18th century described the cultivation of cereals, olive shrubs, vineyards, and figs, alongside the extraction of salt and rosin and the collection of acorns for leather's treatment (Yagku, 2003). For example, a diplomat from Netherlands described the cultivation of cotton, grape, olive, lemon, orange, nut, and melon (Douma et al., 2016). From 18th century onwards the agricultural economy of the island was based almost exclusively on the monoculture of the olive shrub (Yagku, 2003). The demand of olive oil was higher, and the exportable value of cereals was reduced because granaries were built in Macedonia and Asia Minor. Later, in 1867, an increase of agricultural production and exports of olive oil, soap, acorns, cotton, silk, wool, fruits, wine and ouzo (traditional alcoholic drink from grapes with anise) took place. Cereals, sugar, coffee and rice were then imported.

The first decade of the 20th century, Lesvos produced 3,840 tonnes olive oil per year for human consumption and soap production, therefore the olive shrub cultivation was dominant. Similarly, around to 3,000 tonnes acorn was collected from wild oak trees. Other fruits (figs, oranges, sultana raisins, pears, pomegranates, apples, quinces, peaches, cherries, apricots, walnuts, almonds and chestnuts) and vegetables were also cultivated, and the largest part of the production was exported (Douma et al., 2016). Cereal production was sufficient only for 2-3 months for population needs. In the center of the island tobacco was cultivated, the arrival of refugees from Asia Minor in 1922 boosted tobacco's plantation. The cultivated area in 1950 was described with olive orchard to dominate with 45,000 ha, fertile arable with 30,000 ha and 850 ha vineyards covered by vineyards. The last 50 years, demographic changes due to urbanization and international migration have affected "the percentage of population engaged in full-time farming agriculture". On top of that, agricultural land uses were replaced by tourism related construction activities. Simultaneously, abandonment of mountainous villages or their inhabitation mainly by elderly people have changed the crop distribution; olive plantation has expanded with abandonment of orchards and vines. Last but not least, grazing dominated the cereal area which had been gradually reduced to the half of it. The last 80 years grazing land has increased to double (Douma et al., 2016).

Nowadays, 28% of the total area of the island is covered by olive orchards, 9% with other crops and fallow areas, 38% pastures, 19% forests and 6% with other areas such as towns, villages, roads. In 2016, the production was: 20,748 t of oil, 1,267 t of oranges and lemons, 6,589t of tomatoes, 5,292 t of potatoes, 7 t of wheat etc. Vineyards cover only 0.7% of the total island area and together with tobacco and cotton and flax plants have disappeared. Anise is mainly imported for the ouzo production.

However, olive shrubs and pastures dominate the landscape (see Figure 4.4); the wide diverse flora enriches it; 1,279 species and 237 subspecies, with 14 of them to be endemic in Greece, and 3 of them exclusively on Lesvos. (Douma et al., 2016) documented the spatial distribution of the number of crops, with emphasis on fruit trees. In this study, they recorded species in two expeditions and conducted several interviews. It also presents the spatial distribution of landraces on Lesvos and provides agronomical and historical information about the current annual and perennial landraces. Hundreds and even thousands of years of landraces' introduction and evolution have formed an agricultural diversity on the island. The last was mainly driven by a. the farmer's selection and b. the adaptation on a continuously changing environment. High socioeconomic, cultural and heritage value arises from the landraces which are strongly related to the island's heritage. Landrace's conservation has been threatened by the replacement of the traditional farming systems by modern agricultural practices, agriculture's commercialization, and the deterioration of natural ecosystems in combination with the changes in consuming patterns, legislations and market forces, which restrict the crop varieties. Narrow genetic base of most major crops dominates agriculture's spectrum nowadays. According to the Food and Agriculture Organization of the United Nations (FAO) 75% of the agricultural biodiversity has been gradually destroyed during the last century and this trend will probably become even more severe in the near future. Food securities, functionality of agroecosystems, social equity, economic growth, and potential innovations in agriculture have been challenged by the on-going erosion of agrobiodiversity. However, in Greece, the geographical patterns, such as isolation of islands or hilly and/or mountainous areas with the social conditions and the small-size farms, there are landraces still under cultivation, especially in islands and marginal regions (see Agricultural production nowadays) (Douma et al., 2016).

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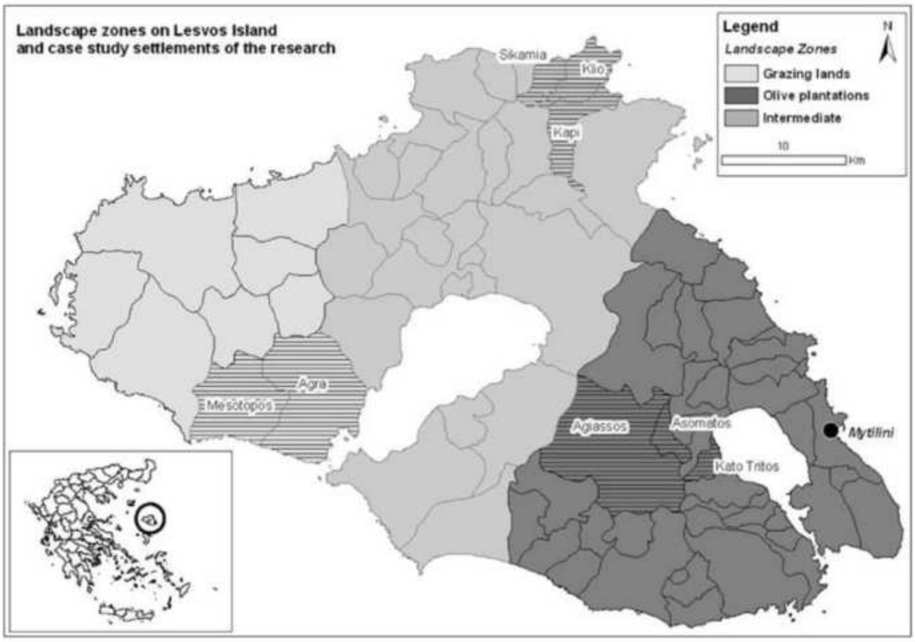

Figure 4.4 Landscape zones on Lesvos Island

Source: (Kizos, Dalaka, & Petanidou, Farmers' attitudes and landscape change: evidence from the abandonment of terraced cultivations in Lesvos, Greece, 2008).

4.2 Agricultural stories at Antissa during the last century

Antissa's population has been decreased constantly the last decade. Nowadays, around to 800 inhabitants live during winter in the village of Antissa, 100 among of them to work as public servants (Lambrinidis, 2018).
Stravros Sfihtelis from Antissa published in 2012 the book "In the paths of Antissa" (Sfihtelis, 2012). In this book he narrates stories among them some on the habits related to agricultural practises in the previous century in the region of Antissa. He has been active member to the association of locals of Antissa in Athens "Aghios Ioannis Theologos" until curently. Below, selectively, stories from this book have been translated to English and presented.
Antissa was called Telonia and the first settlers arrived approximately 400 years ago. Telonia was a town with 3000 habitants until some decades ago.

Olive grooves

The cultivation of olive shrubs in the region of Antissa is very old. Old trees and trees from specific varities are identified nowadays in the region. However, it took place in specific regions of Antissa. In January 1850, frost damaged many trees; the damages were so high that people quit the olive cultivation. Frost occurrences cause damages in 1928, 1962 and 1987 as well but in smaller scale. Nowadays (2012) in Antissa, 100,000 olive shrubs are cultivated which produce on average 500,000 kg olive oil.
95% of the olive shrubs are the variery adramitini or adramitiniani/milioelia (Αδραμυττινή ή Αδραμυττιανή (μηλιοελιά)), the rest 5% are varieties such as thuboelia, dafnoelia, kolovi (θρουμποελιά, δαφνοελιά, κολοβή) etc. The Adramitini is the one which covers all the northwest part of Lesvos, and it covers 30-35% of total olive shrubs on the island which is 12 million. The color of the

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olive oil which Adramitini produces is like golden pound andthe fruits are eaten as tsakistes elies, klastades (Τσακιστές ελιές, κλαστάδες). The olive shrubs used to be cultivated in past centuries. The massive cultivation was after 1930. The oak trees were replaced with olive shrubs from 1945 to 1960. Since 1949, there is an association of olive producers.

There are many reasons that olive shrub cultivation had been boosted for example a) acorn's price was reduced, chemicals substances replaces the acorns in the tanning (leather) industry, b) machinery for olive oil production was improved, c) experienced local farmers supported a lot on replacing the oak trees with the oak trees, d)irrigation was supported with boreholes, either boreholes or water which was transported with mules in hard paths for long distances until the second world war when plastic small tanks were introduce for water transport and it became a bit easier.

Tobacco

Tobacco cultivation had mainly been expanded since 1922. At Mithimna in the Antissa region, 1,000 ha of tobacco used to be cultivated (see Figure 4.5). Tobacco and oak cultivation were the main income to most families in those years for almost a half century. The cultivation of tobacco kept busy the farmers for the 12 months of the year. The irrigation was with buckets from the wells and animals or by hand were transported. Among tobacco plants where some space was left, they used to cultivate tomatoes or melons. Nowadays, the cultivation has been totally interrupted.

Figure 4.5 Tobacco cultivation at Antissa. Source: Sfihtelis (2012)

Legume & the Drying floors- alonia

Antissa had been always one of the largest producers of legumes and cereals in the region from to 1920 to 1950. For example, only at Mithimna, the land with cereals was 4,550 ha or 46,500 acres and legumes 870 ha or 8,700 acres. Every agricultural house used to have an "aloni", the drying floor specifically for the grains. The rest of the year it was used for other purposes as well such as drying the grapes, the acorns, the figs, the beans, the Tarhana etc.

Acorn

Acorn production has been for many years one of the most economically important product at Antissa. It was applied to the tanning (leather) industry until 1970, when it was replaced with chemical and other substances. Antissa and Vatousa were the two regions with the highest production. Gavathas village in the region of Antissa was the largest "export port" in the country, the supplier to the largest industries in Greece. The production was annual, on top of this, the offer and demand was fixed. The last one contributed to support the local economy. The farmers fed with acorns the animals. The wood from the oak tree was used for heating in the winter, for cooking, for baking bread in the wooden

ovens and for construction material to livestock houses-barns or stables or dhamia “The Dhamias were small, dry-made buildings made of dry stone built by farmers and stock farmers in the fields, in their estates. Oak wood was also used for the construction of the “Isiodio arotro””. (Agriculture, 2018)
“Zones” of oak trees were dominant on the northeast part of region of Antissa’s landscape, both on the hills and plain. There is lack of availability in the statistical data, however an estimation of 1,500 tonnes acorn were produced per year by 150,000 oak trees in a region of 10,000 acres, 1000 ha, i.e. 1 tree produced 10 kg acorns.
The forest oak trees did not require a lot of working effort such as plowing, pruning or fertilizing. They could be even cultivated in the non-temperate soils. They were names based on their size in local dialect such as large trees as valanidies, small trees as valanduria and the young ones rupakia, the Greek name of them is velanidia. Every September, the harvest was taken place. In August, the harvests of the “afats”, the fallen crops on the ground were collected. The afats were the 5% of the total production so a small but important contribution to the total income.
The harvesting period was like a local fest. Mechanically harvested acorn was obtained by shaking the tree and collecting the fruit from the ground by hands. The shaking was a dangerous job which required a talent, done by a man. Mothers and children were mainly collected the acorns from the ground. Grandparents support later in the removal of outer layers of acorns. Nowadays, the remained forest oak trees do not produce acorns. This is partially explained from the lack of pruning these days: the shaking during harvest function probably simultaneously as a pruning of the tree. These habits and the production of acorn was declined and stopped by the mid-60s.
Around the harvesting of acorn, the “basak”, an unwritten law was established during 50s-60s. Boy - children from 5 to 16 years old from the village were getting a basak. Basak was the generated income from collecting the acorn from the ground or from non-harvested trees. The children with the “gatzuridi” a long wooden stick around 3-4 m could shake the tree. The basak period was from 20th September until end of October in the weekends. The unwitten law was that a. none of the children would collect accorns from a field which was not harvested first by the oweners and b. nobody would shuffle his basak with the last quantities from acorn form his family. Basak was also applied to other cultivations such as to the peanuts and later to a potato field in the region.

The earthquake in 1889 damaged many properties on west part of the island with 36 human deaths. The community received solidarity support from the east part of the island. However, the greatest support was the increase of acorn’s price from 11.5 to 15.2 English pounds. The acorn was the precious’s product of the region.

Vineyards

The cultivation of the vineyards in the area of the Antissa village but also in West Lesvos in general is very old and is lost in the depths of the centuries. Many ancient poets and authors wrote about this wine quality. For example, the Latin writer Plinios (23-79 AC) in his work “Natural History” refers that Romean would preder from all the wines the wine from Lesvos which was very beneficial for the recovery of patients. Few ancient spots, the “lini” nowadays “patitiria”, for wine press with human foot are identified in the region. A linos was usually 2 m long with 1.2 m width and 1.4 m depth.
In 1936, according to statistics, the production in Mithimna region was around to 5,000 acres (500 ha), and nowadays around to 1,000 acres (100 ha) and in Antissa up to 100-120 acres, 10-12 ha.
In 1950s the vineyard at Antissa was up to 1,000 acres, 100 ha. Every family in the village, Agricultural Family or not was owner of its vineyard. The vineyard cultivation was close linked to the family’s diet and life during the year apart from the grapes in the summer period such as the production of wine, vinegar, mustalevria “a traditional Greek kind of pudding made of grape must mixed with flour and boiled until thick”, ouzo (local drink with anise), cognac, grape sweet spoon, vine leaf rolls, leaves for livestock, must for medical purposes, dried vine fruits such as raisins and the wood for fire.
The largest vineyard zone was close to the seaside region at Gavathas and Kampos, 100-200 m away from the beach. The size of the vineyard was up to 500 m wide and the length equal to each beach.

These areas are with sandy soil, easy to work with, inadequate for other crops and produced high quality of grapes. There was a rich variety of grapes. The most famous for wine'production was "kalloniatiko" and for must's the "tenedi" originated from the island Tenedos.

Figs

Fig production was very important for the region, the island and actually Greece; fig export represented the 20% of exported value before the World War. In 1951, the fig production on the island was around to 750 tonnes compared to nowadays which reaches the 10 tonnes. The total island's production was concentrated to the three fig laboratories at Ipios (see Figure 4.6), Kalloni and Eresos. The process of disinfection, treatment, packaging, and delivery took place in one of the 3 laboratories under the supervision of the company "SIKIKI" based on Kalamata, South Greece. It is estimated that 1,100 fig trees at Antissa and 9,700 trees at Eresso are identified nowadays. In the past, fig trees were all around the region and there were no fig orchards like at Eressos. The main variety was the "politika" (see below section figs for varieties).

Figure 4.6 Packing of figs at Ipios in Lesvos in 1950

Source: (Sfihtelis, 2012)

Irrigation

The 1950s were one of the most important decades in the local development. However, migration domestic or abroad was dominant; the technology's development boosted the local life conditions. The irrigating farming was just starting. The first "motors" to pump water from rivers or to access to wells had just arrived in the village and would change the farming methods. Local farmers initiated and attempted to various spots to extract water, but they soon realized that often water was brackish. The mainly irrigated farming was potato cultivation. They were cultivated early August and harvested from early November. Then, watermelon and melons, "bostani," were irrigated. Around 1970s, these cultivations were replaced by clover-midiki for feedstock to the livestock.

Traditional pitchers, wells and water fountains

Antissa, Telonia as used to be called, was chosen by settlers because they could cover their needs for water for the family and livestock. Water was concentrated in simple technical ponds, the kazane, which was directed to the water fountains, "vrises". Pleny of fountains were located all around the village, the quality and quantity of water was different to each, for example at the fountain "fsid" water was not potable. Women used to transport water from the fountain to home with the traditional pitchers with children's support. During winter they shall take care to store some water at home because the foutnains often were frozen. In those cases, the consumption was minimized and there was an effort to recover water from the roofs when the snow melted.

Fruit orchards

Antissa was never famous for large productions of fruits. However, fruit bearing trees of the region produced large quantities to supply the habitants. Fig and pear trees were more dominant. Apart from the vineyards, watermelon and melons were most cultivated. The lack of options to conserve the fruits did not support larger productions. However, it supported to develop a "solidarity" market in the region i.e., the producer of pears would keep part of the production for his-her family and would share baskets with the rest to the extended family and friends. Similarly, the producer of figs would share part of the production. In this small ecomical scale, this exchange process provided with fruits more habitants. Lack of knowledge did not also support the fruit production, for example, there were no knowledge of the grafting potential.

Below a list with more dominant fruit production including the name in local dialect Cherry plum or damson, Irikia in Greek, koromila or tzanera in dialect. These trees were most found in the house yards. They were the first fruits which ripened every year. Apricots, "Verikoka" in Greek. Berries, "Mura" in Greek, "Skamia" in dialect, they were not actually harvested but directly consumed from the tree. Watermelon, "Karpuzi" in Greek, was one of the examples for non-irrigated farming. Two main watermelon varieties: a. alatzades and b. lires. The large ones were around to 5-6 kg. The large ones were also used as decoration to the windows or were hidden under the sofa to maintain it for later consumption.

Melon, "Peponi" in Greek, non-irrigated farming. Three main varieties of melon were cultivated: kasidiarika, filota and himoniatika. The last means "winter" in Greek, they were stored or decorated until to ripe and were consumed late Autumn or Winter. The cultivation was often damaged by rabbits or hedgehogs.

Grapes (See above section Vineyards) Vineyards dominated the agriculture landscape. Every family was owner of such field. The family's diet included many products from this farming. The main grape varieties were; kalloniatiko, fileri, tenedi, beileria, ktures, kirtixidika, kantines, savatiana, fraules, moshata, kotsnagerata, eftakila etc

Figs, sika in Greek (See above section Figs). Figs were the main fruit of the region. They were consumed either fresh during summer or dried with basilikum in the winter (called apla-simple or alkutzies). Basilikum adds a flavor and keeps away the insects. Fig trees were found all around the region of Antissa and counted up to 2,500 trees. The main fig varieties were in order politika, aidiniu, prasinosika, platosika, marska and mavrosika-the black ones consumed mostly fresh.

Pears, ahladia in Greek, apidia in dilect. Pear trees were also all around the region. The main pear varities were kontules, asprapida, vasilikapida, kolokithapida etc the last were consumed late autumn or winter.

Autumn fruits, Pomegranates and quinces were produced in small quantities. The quinces were the snack for children in the school break. Other fruits such as peaches (rodatsina in dialect) and plums (burdeles in dialect), apples and sour cherries (visina in dialect). Last, photos from Lesvos in 1970s are presented on this website (Lesvos news, 2018).

4.3 Landscape changes in terraced fields on Lesvos

"Kizos, Dalaka, & Petanidou, Farmers' attitudes and landscape change: evidence from the abandonment of terraced cultivations in Lesvos, Greece, 2008" examined farmers' practices in order to describe the landscape change in terraced fields on the island and identify these processes. According to this study, agriculture is still a key factor to the provided income, mostly in rural areas, however the number of farms has dropped around 20% from 1970 to 2001. Olive plantations and grazing lands for sheep are the dominant agricultural land uses. Their research is based on questionnaires to farmers focusing on what the reasons for these changes, maintenance's practices and how farmers perceive this landscape change. Farm's structure is considered the cultivated area, animals and land uses. With the term "landscapes", two different scales are described, a. farm-level landscapes related to the individual farm households and b. larger scale landscapes which are the sum of the farm-level ones. The study shows that similar cultivations and landscape management practices are employed on farm households even if the income varies among them. The agricultural census shows that larger farms are in the western zone of the island and the other two areas are small and close to the national average farm size (i.e., 4.4 ha). (Kizos, Dalaka, & Petanidou, Farmers' attitudes and landscape change: evidence from the abandonment of terraced cultivations in Lesvos, Greece, 2008). Eight cultivation practices on terraced fields were recorded in olive plantations with almost all farm households applying picking the olives and pruning. In decreasing order these practices were reported: ploughing of the understory, fertilization, and plant diseases protection, irrigation, harvesting of the understory grasses, and mixed cultivation (growing arable crops in the understory). The combinations of them were also many. Around to 14.5% reported organic olive plantations.

The changes of farmer's practices and therefore the farming systems had changed gradually and slowly the rich cultural landscape. The landscape has been dominated mostly by tree cultivation with little ''modern'' practices, therefore the rate of change was delayed. The aging farming population creates an unstable farming stable. Major cultural, ecological, and physical impact upon the landscape is expected due to the marginal policies for terraces' reconstruction or maintenance. The findings indicate that the latest appears" irreversible and puts the whole landscape at risk". Last, regarding the views and attitudes of farmers, for a number of reasons the landscape of their area was very dear to them. They were pessimistic for the future due to the lack of motives to the younger generation to become farmers. Even if subsides make sheep husbandry profitable, the work is hard.
(Karampela, Kizos, & Kavroudakis, September 2017) refer further regarding that local agricultural and agri-food economy is shaped by olive oil production, sheep husbandry for cheese production and the production of the alcoholic drink ouzo. Figure 4.4 shows eastern part of the island consists most of olive plantations and the western of grazing land. A characteristic for Lesvos and part of its local identity is the homogeneous landscape by the olive plantations; the trees mainly are lying on the sloping fields. Therefore, "olive island" is the informal name of Lesvos. (Douma et al., 2016).

4.4 Agricultural production nowadays

Within the context of the project '1G-MED08-12 AGRISLES', (Douma et al., 2016) gathered information about germplasm collected on Lesvos. Later, they conducted two expeditions for landraces on Lesvos, mostly in remote areas; in 2011 and 2012 their study covers a substantial portion of island's area including approximately 350 interviews with inhabitants, professional or amateur farmers. Based on this input the following results including some factors of randomness. The results of the study show that there is an inestimable genetic wealth of cultivated species especially regarding trees and vineyards on Lesvos Island. Locals appreciate the local varieties even if new have been introduced on the island. There is an urgent to promote this biodiversity which can direct to the economic sustainable development of the island.

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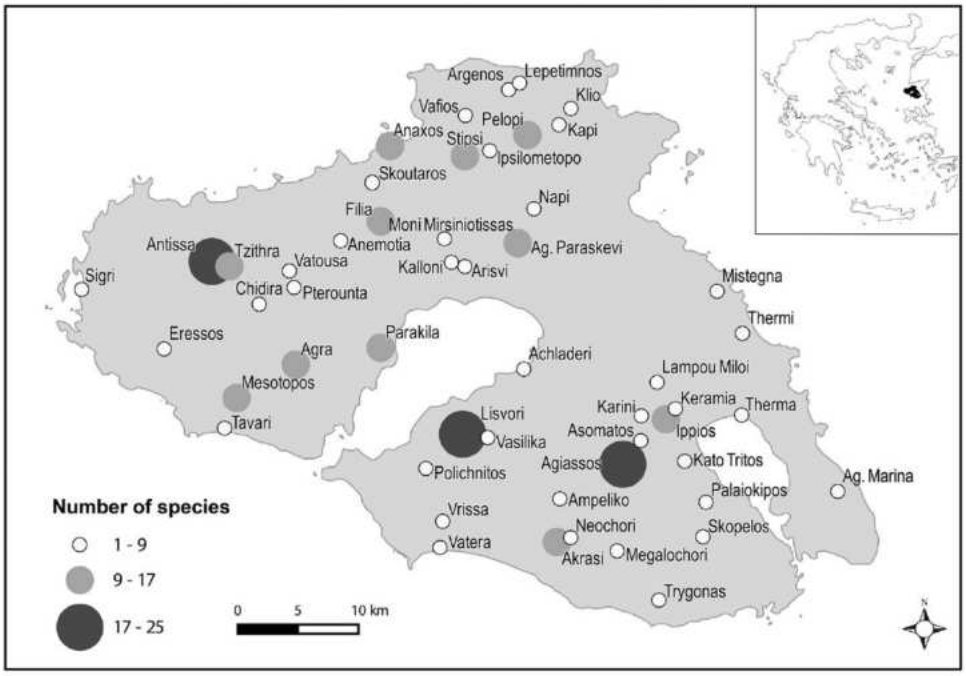

Figure 4.7 Spatial distribution of the number of crops

Spatial distribution of the number of crops, including fruit, species recorded per surveyed village in Lesvos Island. Map created with QGIS 2.6.1 'Brighton. Source: (Douma et al., 2016)

4.4.1 Annual and biennial crop species

The study examined 309 accessions, belonging to 36 annual and biennial crop species and botanical varieties with a majority of vegetables, followed by pulses and cereals. Antissa was included in the recorded spatial distribution of local genetic material (see collected accessions at Antissa per species in Table 4.1).

Cereals

"The best that one may get and the finest in the world. It is whiter than snow from the sky. If it be so that the gods eat barley-meal, Hermes must go and buy it for them there." with this saying the barley was praised by gastronomer Archestratos in Eressos in 4th century BC. Wheat and barley have been linked to the history of the island since the ancient times and the abandoned mills across Lesvos testify this as well. Tradional wheat crop is considered the Triticum aestivum L. and T. durum Desf., tradional barley crop is the Hordeum vulgare L. In the 5th century BC Lesvians used barley to prepare the 'Krimnitas' or 'Chondrinos' a kind of bread.

In 1946 cultivation of wheat landraces dropped from 70% of the total area in 1946, to 25% in 1958.

Drought resistance is considered the red wheat 'Kokkinostaro'. Landraces have been very heterogeneous with many varietal forms.

Nine different cereal accessions were found with 1/3 of it to be wheat; barley and oat landraces are still active but whereas sorghum (*Sorgum bicolor (L.) Moench*) and rye (*Secalesereale L.*) have vanished. Consideration shall be given to maize (Zea mays L.) because only one sample was collected. An indication of an alarming situation is the extent erosion which was observed in cereals landraces which makes unique the grain samples.

Below a list with wheat names that were cultivated in the past; ‘Deventesi’, ‘Gymnostaro’, ‘Canberra’, ‘Kolovo’,‘Montana’, ‘Spanostaro’.

‘Asprostaro’, ‘Saritsam’ and ‘Sparos’ are the three landraces which survive today. Except of ‘Canberra’ and ‘Montana’, the rest were foreign cultivars introduced for production improvement in Greece.

One of the reasons which forced the abandonment of the cereal landraces is the lack of machinery to harvest seed crops to be used for next year’s sowing resulted in the abandonment of the cereal landraces.

Nowadays, some flours mill of small capacity is operated. Some of the cereal corps have a great potential to cover livestock needs (sheep and goats) and reduce the import of feedstock.

Pulses and forage legumes

Pulse diversity on the island seems rich. Twenty-seven from the forty-eight collected accessions belong to common beans, *Phaseolus vulgaris L* and fourteen to cow pea or blackeyed bean, *Vigna unguiculata (L.) Walp*.

Some local names for the beans are

‘Barbounia’(namely red mullet = butter beans), ‘Fragkofasoula’ (Frank beans) or ‘Chires’ (Widows), ‘Lopia’, ‘Phasoli of Kapi’ (beans of Kapi village),‘Pritsikelia’, ‘Tsaoulia’, ‘Zarganes’, ‘Asprofasoula’ (white beans) and for the cowpea or blackeyed bean (*Vigna unguiculata (L.) Walp.*) [localnames: ‘Aspromytika’ (with white nose), ‘Mavromytika’ (with blacknose), ‘Picheos’ (cubit sized)].

In the village Lisvori, there is a famous chickpea (“revithi”) landrace which is the only one on a relative large scale on Lesvos. However, it is not competitive enough to the imported chickpea because it is sold in bulk instead of packed. The peas and beans are mostly imported from Canada and chickpeas from Mexico and Argentina according to a local merchant. Last beans and cowpeas are consumed also as vegetables.

Vegetables

Vegetable landraces are still in operation. Household demands and the small area of land which they require have preserved them. Elderly people mainly still grow in home gardens and backyards. On Lesvos Island,

multicropping systems, traditional farming practices, small scale farms and home shape a traditional farming system with high vegetable diversity. Twenty-five vegetables species were collected with numerous accessions of some such as tomato (*Solanumlycopersicum L.*), pumkins (*Cucurbita pepo L.* and *C. maxima*), cucum-ber (*Cucumis melo L.*), aubergine (*Solanum melongena L.*) and okra (*Abelmoschus esculentus L.*) Moench. n contrary, few accessions of pepper (*Capsicum annuum L.*), cabbage (*Brassicaoleracea L.*), celery (*Apium graveolens L.*), onion (*Allium cepa L.*), and lettuce (*Lactuca sativa L.*) have been collected.

For market purposes, a small number of number of landraces (tomato, melon, cabbage, aubergine) are cultivated for various reasons: a. Their yield is lower than commercial ones, b. some characteristics of them such as shape or bitterness (cucumber) are not acceptable by customers c. short postharvest shelf life, d. lack of seed or propagating material. It is generally agreed that farmers’ attitudes and social networkingare critical for the improvement and preservation of biodiversityin agricultural landscapes.

Other crops

Sesame (*Sesamum indicum L.*) and anice (10 ha) (Pimpinellaanisum L.) are cultivated at Lisvori region. However, anice does not meet the reqiremend and it mainly imported from Turkey or Northe Africa. The cultivation of cumin (*Cuminum cyminum L.*) at Lisvori has almost disappeared.

4.4.2 Perennial species

Olives

Olea europea L. is the dominant olive shrub varieties on the island covering the largest part of it. It generates the most income in term of crops to the inhabitants. Two ancient Greek cultivars, Kolovi' and 'Adramy-tini' or 'Aivaliotiki' are still cultivated on the island of Lesvos. These two landraces together with the Karolia', 'Ladolia'and 'Dafno-lia' have the largest spatial distribution. Non Lesvian landraces are also reported. After the extreme frost of 1850, extensive replanting with the 'Kolovi' and 'Adramytini' vari-eties have been taken place in most areas in Lesvos. 'Adramytini' is considered that with-stands successfully low temperatures.

List with Lesvians

'Kolovi' (tailless), 'Adramytini' or 'Aivaliotiki' (from Aivali, a city of Asia Minor, calledtoday in Turkish Ayvalık), 'Karolia', 'Ladolia' (oil olive), 'Dafno-lia'.

Vineyards

The island was famous as wine producer. Numerous names of varieties were recorded even if grapevine's production has been declined dramatically. In 4th centrury BC, Archestratos praised the Lesvian vine saying that "Lesbian [sic] will seem to you to possess the glory of ambrosia ratherthan wine' (Athenaeus, Deipnosophistae 1.29c)."

Wine from Kallloni in an early 20th century was famous. Nowadays, the scale cultivation is short mostly by amateurs who also grow old varieties. Vine cultivated for wine overs 140 ha and for tables varieties 70 ha.

Fruit trees

More than 140 varieties names (landraces and improved varieties) were recorded including 13 diverse species. Since ancient times, fruit tree crops have been traditionally cultivated e.g figs and others have lately been introduced. The interviewed farmers, most amateurs or pensioners, were around 60 years old and cultivate for personal use. Only around 30% were full time farmers. The highest diversity was recorded in pear trees, around to 40% of the total, followed by figs and apples. The majority of local fruits vegetables are hosted on the mountainous area of Agiassos.

A "linguistic wealth" has been observed on the name of each variety and it is linked strong to the cultural. Shape characteristics of the fruit or geographical elements e.g., the main area of cultivation are reflected in the name, for example "Avgosyka" (egg-figs), or "Politika" (originated from Istanbul). Funny names related to animals or vegetables or the name of the farmer who introduced it on the island or cultivated are also used, e.g., "Skilapida" (dog-pears) and "Chasogianni".

Pears

Fifty-four varieties' names of pears (*Pyrus com-munis L.*) were recorded in 29 villages which most of them considered as landraces. According to farmers at Agiassos area, pears trees require minimum effort for treatment; they require only pruning and no fertilizers. The most landraces are well adapted and show relatively high resistance to pests. Due to lack of facilities for fruit's conservation and storage, the farmers do not trade but many farmers sell part of the harvest directly to consumer in the neighboring villages as street vendors. Around to 40% of farmers own significant number of pear trees, however, they leave them unharvested, so the fallen fruits will be feedstock for the goats which graze in the area. Pear trees are identified all around to the islant regardless of soil type and at heights from sea level to more than 500 m above it. Achtses', 'Kountourelia','Kakavia', 'Miskapida' and 'Moutzourites' are in the highest quantity of landraces' names (See Table 4.2). Despite the high diversity and adaptability to local climatic conditions, pear trees are threatened by genetic erosion and extinction as a rapid reduction in the numbers of surviving trees is evident.

In the deliverable report of Agrisles project, (Douma and Galanidis, 2013) refer details on the production of some of varieties.

Achtses or Zacharapida trees are the most common pear trees on the island and are found either next to the seacoast or to heights up to 700 m. They are detected in Antissa as well (see Table 4.2). Their production depends on the height, for example, scattered trees among olive groves produce 20-40 kg per tree or at higher heights up to 100 kg. Nowadays, the largest pear orchard is the one with 350 trees at “ktima Simantiri”. The life of the tree is around 12-14 years. According to Strati Panteleli, the harvesting used to take place by “taifades”, an organized team of 5-10 workers who harvested the pears from the large orchards or other scattered trees. The pears were spread in a stockpile, then women used to choose and structure them in trays which would travel to the capital of the island, Mytiline or further. Chios island was considered a “good” market.

“Kakavia” pear tree were found in the region of Agiasos. This tree is very large, and its production overcomes the 50kg. It prefers the acid soil qualities. Around to 6,000 “Kountourelia” trees are at Agiaso. This variety produces from 40 to 200 kg per tree. The fruit is big and heavy, it can reach the 1 kg. They are winter type and ripen end of September. It is said that before harvest, raining shall precipate so that they get their special colour and glossiness. “Mouzourities” trees are large and produce up to 600 kg pears per tree. This cultivation has attracted women’s associations the last years. “Miskapida” pears are used for the traditional sweet. It’s production is also large up to 800 kg per tree. Around to 5,000 “Tsiluparmata” trees (tselepi+armu in Turkish means pear to give to the tselepli, a type of administrator in Tourkish authority) were detected in Agiasos. The tree produces 50 kg and it has short life time around 15 years.

Apples

Nineteen names of apple (*Malus domestica* Borkh) varieties were recorded on the island mainly at high elevations, in mountainous area of Agiassos. In the past decades, farmers used to trade to Northern Greece quantities. Apples can be preserved in cool and dark place without special facilities for long time, until early spring.

Figs

Isolated fig (*Ficus carica* L.) trees or fig orchards in arid zones are recorded all over Lesvos (see landraces of fig trees of Antissa in Table 4.3). The seconds are most found in the area of Eressos, in the western part of Lesvos. The shallow soil in the region is composed of volcanic deposits which makes it appropriate for fig trees. The interviewed farmers do not apply any chemical fertilizer or phytosanitary products, the trees adapt well to the local environmental conditions. However severe pruning was applied in the past nowadays renovation pruning and rejuvenation in old trees are more commonly applied practices.

There is a sharp decline of area occupied by figs and has been replaced with crops such as alfalfa.

These crops consume a lot of water and the water reserves in the region are limited. In addition to this, fig orchards have been transformed to pasture lands.

The common size of groove with fig trees is small around to 1 ha, 10 acres.

Nowadays, the farmers feed mainly the local market of the island with dry figs, although in the past decades, there was a significant export even to North Africa, France and USA (around to 300 tonnes around 1910, and 200 tonnes until 1970s). Twenty-five landraces’ name was detected. Vasilika variety which means royal therefore very good quality is such an old landrace which was reported by ancient philosopher Theophrastus.

(Douma and Galanidis, 2013) refer that three fig-associations were in operation until 1970, at least 100 women worked there for the marmalade production, sweet spoons and the tsipouro, a traditional drink. The harvest takes place with collecting the fruit from the ground except from the Aidinia variety. Aidinia variety produces large figs which are harvested direct from the tree to maintain their high price. Last, traditionally, the drying happens according to the moon phase, so that worms would not grow in the fig.

Oranges

Orange (*Citrus sinensis (L.)* Osbeck) cultivation is also reported back to 16th century BC. A significant export was reported until 1980s with 1,000 tonnes traded in Turkey and North Greece. Interviewed locals referred to orange as the "Gold" of the area in the past. The variety "Koina" which means the "common ones" has some advantages such as a. late ripening time (March or April), b. long preservation event out of refrigerator, c. high juice percentage and d. sweet taste. Most farmers do not apply chemical fertilizers or insecticides, even not to the Mediterranean fruit fly (Cer-atis capitata (Wiedemann)).

Other fruits

Scattered on the island, cherries (*Prunus avium (L.) L.*), sour cherries (*P. cerasus L.*), round plums or egg plums (*P. domestica L.*), peaches (*P. persica (L.)* Batsch), apricots (*P. armeni-aca L.*), quinces (*Cydonia oblonga Mill.*) and pomegranates (*Punicagranatum L.*) have been detected. They exhibit high adaptability to the local environmental confitions and high resistance to pests. They are plenly all year on the island with women's cooperatives to use them for juices or tradtional "glika tou koutaliou" (spoon sweets).

Douma and Galanidis (2013) detect pomegranates scattered around the island, among them the varieties "Kantinaria", "Lefani" and "Kaisi". It is estimated that Kantinaria trees are very old up to 100 years and produce large crops. Its postharvest shelf life is long; it can be preserved up to March. They are also distinguished by the high juice content.

Nuts

However, nuts cultivation is rare on Greek islands, chestnut trees (*Castanea sativa* Mill.) are reported as an orchard. Nowadays, there is a rename of them linked to the geographical origin as "Kastana Agiassou", chestnut from Agiassos in Olympus Mountain region. The natural chestnuts have been used for their timber and the grafted ones for chestnut production. Although, scattered landaraces of walnut, almond, pistachio, and hazelnuts have been detected, they have been abandoded. (Douma et al., 2016)

Table 4.1 Collected accessions per species at Antissa Source: (Douma et al., 2016)

Genera/species	Common name
Hordeum vulgare L.	Barley
Triticum durum Desf.	Durum wheat
Lathyrus ochrus (L.) DC	Cyprus vetch
Phaseolus vulgaris L.	Bean
Vicia faba L.	Faba bean
Allium ampeloprasum L.	Leek
Capsicum annuum L.	Pepper
Citrullus lanatus (Thunb.)	Watermelon
Cichorium intybus L.	Chicory
Cucumis melo L.	Melon
Cucumis sativus L.	Cucumber

Cucurbita maxima Duch.	Pumpkin, squash
ucurbita moschata Duch.	Winter squash
Cucurbita pepo L.	Vegetable marrow, pumpkin
Petroselinum crispum (Mill.)	Parsley
Solanum lycopersicum L.	Tomato
Solanum melongena L.	Aubergine

Table 4.2 shows names and information about possible landraces of pear tree (Pyrus communis L.) detected in Antissa.

Table 4.2 Landraces of pear tree in Antissa. Source: Douma et al. (2016)

Common name	Description	Ripening time	Postharvest shelf life
Achtses (Zacharapida)	Small sized fruit, sweet, tasteful with nice flavour. High adaptability in variable environments and very productive in high elevations. The most common pears' variety on the island	June	short
Asprapida	Light colour fruit, with no special taste	June-July	medium
Avgades	- Ripening time:		
Avgoustapida (Avgoustiana, Kechrapida)	Large sized fruit, with no special taste-	Middle of August	Medium
Bouzagania (Gaidourapida)	Large sized, round shape fruit, juicy, with lemon taste. High	August	Short

	yielding tree		
Chimonapida (Chimoniatiko)	Small sized fruit, sensitive to pests	July	Long
Lemonapida	Yellow, large sized fruit, very tasteful, with gradual ripening	Late July	Long
Mirmigkapida	Small sized fruit, with sour taste	Late July	Medium
Vasilikapida	Red, small sized fruit, with special flavour and taste	July	Medium

Table 4.3 shows names and information about possible landraces of fig tree (Ficus carica L.) detected in Antissa.

Table 4.3 Landraces of fig tree in Antissa. Source: Douma et al. (2016)

Common name	Description	Ripening time
Aginia (Agikiniotika)	Dark coloured fruit skin, with long stalk	August
Agriosyka	Light coloured fruit skin	August
Mavrosyka (Livanosyka)	Medium sized fruit, with thin skin, dark colour of skin and very sweet	July
Politika	Medium sized fruit, with oblate shape, white-green colour, long stalk, ease of peeling, very sw	Beginning of August
Prasinosyka	Large sized fruit, with thin skin, light green colour, very sweet and with high resistance to pests	August

4.4.3 Medicinal plants

Nowadays in North Aegean, locals treat some ailments with medicinal plants from the region. Some of these are endemic and endangered such as *Sideritis sipylea* Boiss., *Origanum sipyleum* L., *Thymus sipyleus* Boiss., *Pistacia lentiscus* L., *Verbascum ikaricum* Murb. They use the first three for many curative purposes such as infections of the respiratory, (Axiotis et al., 2018). Axiotis et al. (2018) evaluated the status of the traditional uses of medicinal plants in North Aegean and confirm the diffusion of the medicinal plants in traditional medicine. For example, pharmacists on Lesvos use a solution of olive oil with Hypericum perforatum L. and Verbascum ikaricum Murb for wounds and sun burns in combination with modern treatments. The powder of the root of Alkanna tinctorial is applied

for skin regeneration after injuries by clinicians on the island. The healing time of the wound is reduced due to the combination of combined antibacterial and antipruritic action. The study indicates 109 wild plant species from 52 different families in North Aegean that are being used for medicinal purposes.
Similar efforts linked to the traditional used of plants have been researched by Dimitrakopoulos et al. (n.d.). This team conducted an ethnobotanical research from October 2006 to June 2007 in five islands of the North Aegean including Lesvos. They intended to record "the traditional uses of plants as a base for developing innovative business ideas". (Dimitrakopoulos et al., n.d.)
At Agiasos region, where Mountain Olympos dominates the scene, a study on the use of wild/non cultivated plants and the transfer of this knowledge took place by Pitta et al. (2016). The Mountain Olympos is characterized as a region of high diversity (986 m, GR4110005). In the framework of the study 291 uses of plants were recorded out of the 2007 references.
However, these applications were set in a potential use without confirming their use nowadays. The most applied is chamomile followed by nettle, elder, oregano, sage and rosemary. Special attention it is given to the Orchis mascula pinetorum from which salep, a traditional drink is produced. This orchis is protected by the Greek National Law. In addition, Sideritis sipylea, the Greek mountain tea is endangered due to the intensive harvest and its agricultural practices. The transfer of knowledge on collecting and using these plants is through the family networks. Women are considered the repository of knowledge. Many of the applications are not part of the daily life style, so if they are not being reported, this knowledge will disappear.

Plants of Antissa with their medicinal and culinary uses

In the 720 pages of the book "Plants of Greece - a Survey of Lesvos" (Axiotis & Axiotis, n.d.), trees, shrubs, and wild flowers of Lesvos are documented with illustrations and detailed descriptions on their medicinal and culinary uses. Below information about some of the plants which have been recorded and listed in the book regarding the region of Antissa is translated and presented.

Figure 4.8 Mesembryantheum nodiflorum

Figure 4.8 shows a *Mesembryantheum nodiflorum* identified in the coastal area of Gavathas, between in sandy and rocky environment (Axiotis & Axiotis, n.d.).

Figure 4.9 Lupinus varius

Figure 4.9 shows a *Lupinus varius* identified in the valley of Antissa around the fields and at Cleo's olive groves. It is a nitrophilous plant. However, the bitter varieties obtain toxic alkaloids, it's seeds are full of protein. So the seeds shall be kept wet for an evening before cooked. In addition, fungi might be developed to stored seeds. Source: (Axiotis & Axiotis, n.d.)

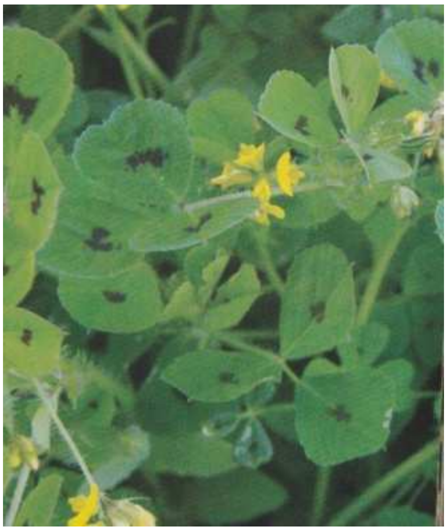

Figure 4.10 Medicago Marina

Figure 4.10 shows *Medicago Marina*, a very common plant on the coastal areas of the island including Antissa. The leaves are rich in vitamins A, C and E cooked or raw. The seeds are edible like flour. Source: (Axiotis & Axiotis, n.d.)

Figure 4.11 Euphorbia paralias

Figure 4.11 shows *Euphorbia paralias*, identified in sandy beaches at Antissa Source: (Axiotis & Axiotis, n.d.)

Figure 4.12 Scandix pectin-veneris

Figure 4.12 shows *Scandix pectin-veneris*, a common plant at Antissa's landscape. It is edible either raw or boiled as salad. Source: (Axiotis & Axiotis, n.d.)

Figure 4.13 Solanum luteum

Figure 4.13 shows *Solanum luteum*, Identified at the beach of Ancient Antissa. Although it obtains toxic alkaloids, its fruits are edible. Source: (Axiotis & Axiotis, n.d.)

Figure 4.14 Otanthus Maritimus

Figure 4.14 shows Otanthus Maritimus, a perennial shrub, it is identified in the valley of Antissa and endangered by human impact. Plant's substances kill the mosquito larvae. The essential oils from the plant and its root have antibacterial activity against hospital microbes like the St. Aureus and the Campylobacter jejuni. Source: (Axiotis & Axiotis, n.d.)

Figure 4.15 Pancraticum Marimitimum

Figure 4.15 shows *Pancraticum Marimitimum*, the “lily of the sea” was recorded in the sandy beaches of the island (Vatera, Antissa’s valley, Lapsarna). It is a protected species which is endangered by tourism development. Source: (Axiotis & Axiotis, n.d.)

4.5 Agrotourism & marketable agricultural products

Agritourism in Europe is promoted as an important tool for its rural development. Kizos and Iosifides (2007) examined the nature of Greek agritourism in three case studies, Lesvos, Magnesia and Lefkada. Since 1980’s when the agritourism first was introduced through EU subsidies to Greek women’s cooperation’s and farmers, it has been grown significant. The main questioned issue is if these activities fulfill the concept of agritourism or “constitute “tourism” in rural areas”. However, it could be argued that the economic diversification based on agritourism is achieved due to the alternative income to farmers from these activities in less favored areas. This divergence between the official objectivities and the reality is highlighted in this study which arises from; a. lack of agritourist identity because most agriculture developers are located in settlements instead of farms, b. absence of marketing support from public sector and management, c. lack of agritourists activities except from accommodation and restaurants, and d. limited local networking. Lesvos island is less known for its mountainous resources and its tourism is d less “conventional”. The island is not easily accessible with the 12 hours boat from Athens, although there is the option of airplane which is more expensive. The last makes the island less competitive in tourist, because it is not easily offered for an extended season for a better income for locals. The total units which offer agritourism on Lesvos are 154; 116 offering accommodation, 14 restaurants and 24 restaurants and accommodation. Apart from olive products, the island specializes in sheep and goat husbandry.
On another study about the agritourism of Lesvos, (Gousiou, Spilanis, & Kizos, 2001) set a similar question if the agrotourism on the island is “Agro” or “Tourism” with the evidence from Agritourist Holdings in Lesvos, Greece. They study exampines its impact on farm characteristics (income, farming practices, and investment) and rural population characteristics (age, sex, permanent residence). Although the agrotourism program successes on income improvement and the willingness to stay in

agriculture, the most holdings are in operation with the same product and “costumers” without the link to the agricultural production or to environmental and cultural landscape conservation. So, the farmers operate agritourism in Lesvos without to fulfil the definition of agritourism.
Zagaria et al. (2018) examined the perspectives of farmers and tourists on agricultural abandonment in east Lesvos to give inputs on discussions on the strategic planning of rural areas which are increasingly abandoned. Their study concludes that tourism sector could support for further valorization of agricultural goods which are based on cultural farming motives and modern cooperative initiatives.
(Kizos & Vakoufaris, Valorization of a Local Asset: The Case of Olive oil on Lesvos Island, Greece, 2011) studied the valorization of the olive oil of Lesvos. Their study includes the analysis of the supply chain of three products: a protected geographical indication (PGI), organic and conventional olive oil considering two dimensions, the size of production and success of the producers. The study indicates that “olive farmers are “cut-off” from the benefits of the products to a great extent”. Most benefits are received by small bottlers, because the big retailers are not involved. The competitive international market is harder to be reached by olive farmers due to the lack of consensus in combination with the absence of common management between the stakeholders on the island.

- NatPro Aegean, a new research center in Lesvos

(Axiotis & Axiotis, n.d. “Plants of Greece - a Survey of Lesvos by Makis & Vangelis Axiotis”) have extensively done research the plants on Lesvos, their work has been also published in the books “Plants of Greece – a Survey of Lesvos. Evangelos Axiotis is in the coordination team to establish the new research center “NatPro Aegean” on Lesvos Island about the promotion of local & traditional agricultural products of the islands of the North Aegean by the National and Kapodistrian University of Athens in 2018 (Program, Special Management Authority of the North Aegean Operational, 2018). This new institute at Geras wille examines certifies and valorizes herbs and other plants from Lesvos to boost their marketable content.

Last, in the book “Local varieties of Lesvos, present…and future?” (Tsiggou), it is mentioned that the “rovi” cultivation, animal’s feedstock has been abandoded, and “lathir” or peas Lathyrus sp. can be found in small quantities for family consumption at Antissa. A list with local varieties describing the advantages and disadvantages is recommended.

Examples of current or potential marketable agricultural products nowadays

- Rosewater production on small scale with traditional methods

Dimitris Xynos and Eleni Sivri at Filia produced rosewater from their plantation with traditional methods (see also figure 4.16). According to (Xynos, 2019) “Our groundmother Vagelio narrated stories about the homemade rosewater production. The plant is a variety of Rosa Damascena, it is perennial and resistant, and it adapts well to the climati conditions of our region. We produce rosewater with the expression method instead of the distillation without water. It consists with more than 90% of Phenethyl alcohol. Every May our grandmother used to offer us “this medicine”, a bottle of rosewater, to preserve it in the fridge. According to the European Mecical Agency (EMA) rosewater is recommended for frequent use like other medicines not only to promote well being but to cure inflammation. Our land is 1 acre, 0.1 ha“

Figure 4.16 Roses at Xynos D.'s farm at Filia

Source: (Xynos, 2019)

- Aronia production

Giorgos Kariofilis, a young farmer, produces bio aronia in Lesvos the last years (bio-aronia-lesvos, 2018).

- Potential other agricultural products

Production of soap from grape's s*tons*, example in Greece from Evagelia Sotiropulu

Milk thistle used as a natural material to produce furnitures, examples Spiros Kizos

Production of Kainari tea, a Unique Greek Traditional Herbal Tea, from the Island of Lesvos: Chemical Analysis and Antioxidant and Antimicrobial Properties (Bampali et al., 2017)

Plant nurseries on Lesvos Island with local varieties

There are two plant nurseries at Mytiline, where local varieties are propagated and sold

- Dimitris Giassas, with focus on pomegranate and fig trees, and
- Manolis Thalasselis, with many varieties of pear trees.

4.6 Community engagement

4.6.1 Inputs from interviews

Personal interviews have taken place which each of lasts last approximately 1 hour (see exemplary fotos in Figure 4.17). The interviewees are from the range of the stakeholder mapping (See Community engagement). Table 4.4 lists details regarding the interviews. The questions categories shape topics linked to the landscape characteristics of the island, water requirements, waste water management, energy production and agriculture. For example, some are listed below. For the comprehensive questionnaire (See 5.5.1 Interviews Questionnaire)

General – island profiling e.g. what would you share about topography, geography, history, and climate conditions on the island and site?

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Water Related e.g. What is the average monthly/annual demand on water per sector-industry on the island and on the demo site?

Wastewater Related e.g., Is there currently any treated wastewater reuse? If yes where is the treated wastewater used for?

Energy e.g. Is the energy local produced or imported?

Agriculture e.g. Are there Biological-organic methods of cultivating?

The meeting protocols are attached (See 5.1.2 Interview protocols) and the mentioned plants are included in the plant list (See 8. Annex Catalogue of selected plants).

Figure 4.17 Interviews with stakeholders

In the left picture, interviews with participants at Mytiline held in December 2018. In the right picture, is a local livestock farmer next to our field.

- Antissa

Antissa's inhabitants are around to 1,000 (1,140 inhabitants, census 2011) and it has been constantly decreased. Among them, 10% of population is occupied in the public sector. Overall, the region is characterized like "west" world with young generation to migrate.

- Fencing technique

An interviewer illustrated the traditional fencing technique (see Figure 4.18). In the region of Antissa, a 10 km structure of this type is preserved.

Figure 4.18 Old fencing technique on Lesvos Island

The large rocks on the bottom structured in a way to form a wall, on top of that "Romania" or "vata", stuffy dried wood was placed to prevent sheeps. The total height is around to 1.5 m.

- Agriculture & Livestock farming

The "psihes", the souls, are called the seeds in the region. From the interviews, among others, it has been recommended to cultivate plants for livestock farming such as "rovi" a clover type. Rovi was cultivated on the island, nowadays it has been tested and it fulfills the standards to feed animals. It is adequate for medium soil fertility. Nowadays, mainly "midiki" is planted for the same purpose, it has a high yield. In Antissa, the farmers are occupied with livestock, so the "easy" period is during the summer and the "very busy" in the winter.

Figure 4.19 Peas's flour production at Antissa

An Antissas's resident, cultivates a pea seed which has kept from his grandparents and nowadays produce flour for personal consumption with traditional techniques (see Figure 4.19). Source: (Aegilops, 2019)
Lapsarda, 10km away from Antissa, is "rich" in water resources, so agriculture is mainly there. In Antissa, there are in total around to 100,000 olive shrubs. The main plantation is clove and midiki for food for livestock nowadays. In the past, watermelon and potatoes were planted in large quantities. During the World War II, Antissa provided the rest of the island with potatoes. The livestock farming constitutes with sheeps around 90% and 10% with goats. Antissa is popular for the cheese production. A museum with traditional agricultural tools will open in summer 2019 in Antissa. The local festival is on 8th of May. Agrotourism is not popular in the area.
There are both large and small farms equally distributed. The agricultural association of Antissa produces olive oil and feeds the wholesaler's market. There are around to 200 members from 30 to 70 years old, 50 of them are active (30-50 years old). The membership is passed from generation to generation. There is no "bio label" branding yet. The best award-olive oil Lesvos constitutes with part of oil from Antissa. The subsidies contribute to half of the income and the rest from selling olive oil. Figure 4.20 shows a homegarden in Antissa.

Figure 4.20 Homegarden or "bahtsedeli" at Antissa

- Acorn production on the island and local architecture

The acorn was used for leather's treatment. During the dictatorship from 1967 to 1974, the acorn's harvest was illegal. The farmers cut the trees, because the leaves had been fallen down, and due to that the, land was difficult to be cultivated. Sixty kg acorn worth 1 English pound (1 kantari is equal to 14 okades which is equal to 60 kg). The acorn production shaped the local architecture. The acorn drying took place on the yards of the houses, on cement floor. The storage building of the farmer was equipped with ventilation. The wholesalers bought from each farmer its production and stored them to larger storages at Lutra and Limanakia in Lesvos. Then, they were transported to the port and sold in Mytiline and Geras in Lesvos. The small acorn was used for pig's feed.

- Water and wastewater treatment

Locals do not "feel" that there is a water scarcity or any water related issue. Since the 2000s, a central water tank is constructed, before that in the summer, they were some issues. The well drilling, waters boreholes have been the main problem in the region, every farm has its own.
The wastewater treatment was the "kiriz", the tourkish one, a domed duct system with s*tons* for each house until recently. The wastewater system at home scale has been replaced since 2010. Earlier, toilets were next to home and clothes were washed in the river around 1970s. Last, the effluent of cheese production is not adequate treated.

Table 4.4 Information on interviews

Interviewee	Persona type	Institution – working activities	Type of interview	Date	Interviewer
1	Academic	Scientific advisor of AGRISLES project, aegilops assocation, public servant in Lesvos	Call meeting	25.Feb .19	ET (ALCN), DK (IHA)
2	Academic	Env scientist, puclic servant at Uni Aegean	In person at Mytiline, Lessvos, Greece	10.Dec .18	ET (ALCN), DK &EO (IHA)
3	Public servant	Lesvos - regional rural development	In person at Mytiline, Lessvos, Greece	10.Dec .18	ET (ALCN), DK &EO (IHA)
4	Farmer	Livestock farmer, grazing land next to HYDROUSA's field	In person at Antissa, Lessvos, Greece	09.Dec .18	ET (ALCN), DK &EO (IHA)
5	Academic	Post doc researcher on ethnobotalogy, in coordination team of the new research center in Lesvos	In person at Athens, Greece	30.Nov .18	ET (ALCN), DK (IHA)
6	Local	Engineer, HYDROUSA's partner	In person at Athens, Greece	08 Nov.18	ET & PK (ALCN), DK &EO (IHA)
7	Academic	Prof, Head of Department, Unive	In person	19.Sep .18	ET (ALCN)

		rsity of the Aegean, Department of Environment	at Mytiline, Lessvos, Greece		
8	Farmer, farmer association , political?	Agricultural Association Antissa, ex president of Antissa's village	In person at Antissa, Lessvos, Greece	20.Sep .18	ET (ALCN)
9	Local, artist, researcher	Doctor, researcher, artist, poems, sketcher, radio producer, tv episodes	In person at Mytiline, Lessvos, Greece	22.Sep .18	ET & JK (ALCN)
10	Local, farmer	Gardener, collection of local seeds	Call meeting, pending	2019	ET (ALCN)
11	Local	Author on local newspaper	In person at Athens, Greece, pending	2019	ET (ALCN)

5. AGRICULTURAL & ETHNOBOTANICAL STUDIES IN LESVOS

36 references to books and journal articles are listed.

Table 5.1 Literature review on agricultural and ethnobotanical studies in Lesvos

Title	Keywords	Author
100+1 Mushrooms, 191 pages	photographs of each mushroom, type of habitat, proliferation, edibility, growing period	By the Society of Mushroom Lovers of Lesvos
Agricultural landscape dynamics in the Mediterranean: Lesvos (Greece) case study using evidence from the last three centuries	Agricultural landscape, Mediterranean, Lesvos, Landscape dynamics, Cultivation terraces	Kizos & Koulouri (2006)
Agritourism networks: empirical evidence from two case studies in Greece	agritourism, network analysis, Lesvos Island, Plastiras Lake, Greece	Karampela et al. (2017)
An Ethnobotanical Study of Medicinal Plants in the Greek Islands of North Aegean Region	ethnopharmacology, traditional medicine, Near East Greek islands, North Aegean Sea, ethnobotany	Axiotis et al. (2018)
Classification of agricultural fields by using Landsat TM and QuickBird sensors. The case study of olive shrubs in Lesvos island.	Agriculture, Olive shrubs, Supervised Classification, Landsat TM, QuickBird, Remote Sensing.	Vasilakos C. et al. (2004)
Contribution to the Flora of Lesvos (Mitilini), Greece	list of 50 taxa of vascular plants from the East Aegean island of Lesvos (Mitilini)	Hansen A. and Nielsen H. (1993)
Database of Biotic Resources of the North Aegean Islands	list of species uses of both the terrestrial and marine environments of the region	Dimitrakopoulos et al., n.d. http://www.ptaba.gr/dyn/

		banner/051716134637_b.pdf
Diversity of agricultural plants on Lesvos Island (Northeast Aegean, Greece) with emphasis on fruit trees	Agrobiodiversity, Genetic erosion, Landrace, sConservation, Lesvos, Island, Greece	Douma et al. (2016)
Economy, demographic changes and morphological transformation of the agri-cultural landscape of Lesvos, Greece	agricultural landscape, economic and socialchanges, Lesvos	Kizos T. & Koulouri M. (2005)
Estimation of the Water Resources Potential in the Island System of the Aegean Archipelago, Greece	Water resources estimation, surface runoff coefficient, management in island systems, simulation models, semi-arid environment, Aegean islands, Greece	Karavitis C.A. & Kerkides P. (2009)
Farmers' attitudes and landscape change: evidence from the abandonment of terraced cultivations on Lesvos, Greece	Cultivation terraces, Landscape change, Olive plantations, Lesvos, Island, Greece	Kizos et al. (2009)
Floristic reports from the island of lesvos (greece) i. dicot-yledones: aceraceae to guttiferae	Aegean, conservation, distribution, floristics, Greece, Lesvos, phytogeography, species, protection	Bazos I. and Yannitsaros (2005)
For my children': Different functions of the agricultural landscape and attitudes of farmers on different areas of Greece towards small scale landscape change	Agricultural landscape, farmers, landscape change, Greece	Kizos et al. (2011)
Grazing land management and sheep farm viability in semi-arid areas: evidence from Western Lesvos, Greece	grauing land, sheep farming, grazing pressure, Lesvos	Psyllos et al. (2006)

In the paths of Antissa (in Greek)		Sfihtelis, S. (2012)
"Instead of 40 Sheep there are 400": Traditional Grazing Practices and Landscape Change in Western Lesvos, Greece	traditional ecological knowledge, agroforestry, silvopastoral, landscape change, Mediterranean, Western Lesvos	Kizos et al. (2003)
Investigating social acceptability for public forest management policies as a function of social factors	Social capital, Co-management, State management, Trust Social networks	Jones et al. (2012)
Is Agrotourism 'Agro' or 'Tourism'? Evidence from Agrotourist Holdings in Lesvos, Greece	agrotourism, rural development, Greece	Gousiou A. et al. (2011)
Knoweledge & harvesting practises of wild plants at Aghiasos, Lesvos (in Greek)		Pitta et al. (2016) https://www.researchgate.net/publication/318208975_Gnose_kai_praktikes_sylloges_me-kalliergoumenon_phyton_sten_Agiaso_Lesbou
Perspectives of farmers and tourists on agricultural abandonment in east Lesvos, Greece	Farmer typology, Landscape change, Traditional farming, Landscape preference, Olive plantations	Zagaria et al. (2018)
Plant communities of Rhododendron luteum Sweet in its unique appearance in Greece, in the island of Lesvos	Rhododendron luteum Sweet, Lesvos	Chrystakis *et al.* (2017)
Plants of Greece - a Survey of Lesvos, 720 PAGES	Trees, shrubs, and wild flowers of Lesvos, medicinal and culinary uses	Makis & Vagelis Axiotis

Present Situation and Development Possibilities of Lesvos' Agricultural Economy (in Greek)		Grigoriou, G.E., 1952
Same Land Cover, Same Land Use at the Large Scale, Different Landscapes at the Small Scale: Landscape Change in Olive Plantations on Lesvos Island, Greece	Landscape change, olive plantations, Lesvos, Greece	Kizos T. & Koulouri M. (2010)
Study of the flora and vegetation of Lesvos island (East Aegean, Greece).		Bazos, I. (2005) PhD thesis
The Contradictions of Agrotourism Development in Greece Ev idence from Three Case Studies	Agrotourism; Rural Tourism; Farmer Strategies; Rural Diversification; Cooperatives; Greece	https://www.researchgate .net/publication/2421811 42 T
The effect of land use change on soils and vegetation over various lithological formations on Lesvos (Greece)	Land use change, Soil properties, Soil depth, Parent material, Desertification	Kosmas C. *et al.* (2000)
The Geography Of Theophrastus' Life And Of His Botanical Writings		Costas A.T. http://users.uoa.gr/~cthan os/Papers/Theophrastus% 20Geography.pdf
The Golden-Green Juice: discussing Olive Oil Marketing Approaches in Lesvos, Greece	olive oil, marketing, Lesvos, PGI (Protected Geographical Indication), quality attributes	Kantsa V. (2018)
The orchids of Lesvos, blog portal		Jan van Lent, http://www.janvanlent.co m/blog/?page_id=519

The role of grazing in terraced agroecosystems of Lesvos (in Greek)		Dalaka, A., and T. Petanidou. (2006) ;
The transformation of landscape: Modeling policy and social impacts on the agricultural landscape of Lesvos		Kizos, T., and I. Spilanis (2004)
Valorization of a Local Asset: The Case of Olive oil on Lesvos Island, Greece	Valorisation, Protected Geographical Indication (PGI), Organic product, Olive oil, Greece	Kizos T. & Vakoufaris C. (2011)
Wild Orchids of Lesvos, 328 pages	Orchids, Lesvos, type of habitat, flowering period, growing areas, location maps	Giannis & Alkmini Karatza
Flora of Lesvos, photos	Photos from flora in Lesvos	https://www.flickr.com/photos/34582597@N05/sets/72157618434950247/

5.1.1 Interviews Questionnaire

Agriculture

- Type of agriculture?
- Which regions on the island are cultivated?
- Do they collect local seeds?
- Traditional methods of farming e.g., terraces?
- Are there Biological-organic methods of cultivating?
- What are the typical sizes of fields? How the land is distributed?
    - Size of field per farmer?
- For what products used to be the island well known in the past? Nowadays?
- What are the irrigation practices? How much does it cost per ha?

Livestock

- What kind of livestock? Sheeps, Goats?
- Where do the animals graze?

Culture

- Local festivals?
- Agricultural festivals?
- Antissa is famous for "..."?
- Cultural heritage – Museum in the region?
- What's the main occupation in the village?
- Tourism sector? What kind i.e agrotourism?

People-Farmers-Association

- Size of Population?
- When is the busy period? When are people more flexible?
- Professional farmers or gardeners? Livestock farmers, fishermen?
- Men, women? Family involved?
- Ages of farmers?
- Number of farmers?
- Size of land per farmer
- Associations; what kind of associations? Type of shares (heritage)?

Commerce-Finance

- What products do they most sell?

- Any branding?
- Type of income, subsidies?

Pains & Gains

What is "the problem" of the region/island?

Water irrigation issues?

Energy demand?

Enterpreneurenial activities

5.1.2 Interview protocols

Interview with Participant 1

Aegilops asociation, public servant, scientific advisor of AGRISLES

Project AGRISLES in 2009, 2011- Scientific advisor Paticipant 1

Recommended plants for the agroforestry design

Ahtses tree: pear tree, very sensitive to transportation

Zartaludia: apricot trees

Plants for livestock which do not demand a lot of water, not midiki-clove

Rovi, old plant used for livestock (it has been found at Agia Paraskevi, genetic test), good for medium soil fertility

It was examined by agricultural uni; sufficient quality for feeding the animals

Plants for dry farming e.g. watermelon (north wind at Antissa)

Teach how to keep dry crops, weed management, how to maintain a farm without much water requirements, a multifunctional farm, with low costs, useful practices

Take care on the local varieties!

General info

Olive shrubs: mainly biological cultivation on the island

At Mesotopos, Tavari village- Giannis Taxiris: they only farmer-producer of bio vegetables on the island

How does the local society react on such events from egilops e.g., on traditional seeds? Slowly but positive in long term

Biological farming and respect to traditional seeds with annual plants at Antissa:

- - Interviewee 10 - hairdresser

Other Recommended replication HYDROUSA cases: Chios Island issues with water.

Interview with Paticipant 2

Environmental scientist, puclic servant at Uni Aegean

Water & wastewater

-enough & good quality of water

-olive groves: type of agriculture that does not demand large quantities of water

-Challenges -Water dam at Tsiknias, from there a 45km transportation pipe network to Mytilne

-Problems on the current water management system: 50 to 60% leak

-Kaloni, WWTP since 5 years ago -> "the reeds treated the waste water"

Plants

-Antissa- Ophrys lesbis, an endemic orchid

Recommendations

-NBS – CW in favor because the currents systems do not work well-not enough funding to run them

Interview with Paticipant 3

Director of Lesvos - regional rural development at Mytiline

Water management

Current situation

Legal & Illegal water-well drilling & issues with salvation

Water management in Mykonos vs Lesvos

Recommendations

Enhance water underground

Village Risvori – aniseed (γλύκανισσο,) chickpeas (ρεβίθια)

Current projects

Funding-subsidies projects to farmers as enterpreneurs

University Aegean, wastewater managemenr related to cheese production

Plants

- Seed collection – Association Aegilopas
    - https://www.aegilopslocalfood.gr/
- Plants related to livestock: corn

Interview with Participant 4

Next to HYDRO 2 field, the river is called Vurgaris

Plants

- Potatoes
- Tomatoes, beans, melons
- Trifili – commerce livestock-high yield, good investment-efficient
- Seeds are called "souls"

Irrigation

- Past-water avlakia with natural/technical small lake collects rainfall->natural flow to the field
- Sandy soil-good quality
- Nowadays-bek, water well drill

Rent fields-payment

- Past with milk
- Now with euros

Fencing

"Romania" or vata-stuffy dried wood-prevent from sheeps

Interview with Interviewee *5*

Research in reverse pharmacology, ethnopharmacology, phytochemistry at Kapodistrian University at Athens

Research center at Geras, Lesvos - NatProagean project (600.000€ funding from the perfecture)

Faculty of Prof. Skaltsounis, Department of Pharmacognosy & Natural Product Chemistry

http://en.pharm.uoa.gr/personnel/faculty-members/pharmacognosy-chemistry-of-natural-products/skaltsounis-alexios-leandros.html

spin-off company "Pharmagnose", dealing with natural products chemistry and biology www.Pharmagnose.com

Journalist on local (largest) newspaper – "Nea tis lesvu"

Recommended plants for Antissa's agroforestry & seeds

Ladana - axistaros

Ladana: "destroyed" during the harvesting period of olives

Ladana grow around and under olive shrubs

(More or less) 1 tn of fresh ladana->500 kg dry ladana->5kg can be used

6€ per kg

Sideritis – endemic @Agiasos, Lesvos

Cannabis-pharmaceutical-clothing

Seeds- data bank prof Malupa-elgo dimitria

General inputs – Lesvos

- Issues on Lesvos with wastewater treatment
    - Olive press -tanks on the farms or fields – not used
    - Cheese industry -> wastewater on the rivers
- Borehole water
- Statistical analysis-businesses on the island
    - Products of olive
    - Fish-
    - Cheese industry
    - (Aromatic plants)

Antissa

Far away from the center of the island

Local news: tv mitilini and newspaper “ta nea tis lesvu”

New Research centers on Lesvos with funding from the perfecture

- NatProagean project from Uni Kapodistriako
- Thomaidis from Uni Kapodistriako (olive oil, wine, honey) with Elgo Dimitra center, essence cosmetics & products

General inputs

- Samos – special orhidees, business with large Greenhouse
- Issues in Greece with the “health claim” / National Chemistry lab in Greece – issues which methodology to approve for certifications

Stakeholders

- Participant 2 – admin employee at Uni Aegean, Env department, trekking, ecology
- Rosewarer producer from Filia, Lesvos
- Diefthinsi agrotikis ikonomias Lesvu, funding schemes, info what ‘s going on Lesvos
- Modusa soc. Association
- Environmental engineer DUTH
- Director of prefecture - soc. Association Paleokipu, very active
- Mayor
- Mesopotamu -soc. Association – the most active association
- Plomari Lesvos at Megaloghori, his olive press- very interesting
- Papagu – soc. Association – director national bank Lesvos

Interview with Paticipant 6

Partner MINAVRA - constructions, streets, wastewater treatment plant (6-7 on Lesvos)

Inputs on Lesvos and Antissa

Island; clear border between east and west, east side is richer

Since 1980-changes on urban environment – health center, telecommunication services, electriciry services, from farmers to public employees

Antissa- 100 people on public sector, from 1,500 to 800 residents at Antissa, # decreases constantly

Water issues

always problem, well drillings at Perivoli since 2,000 more or less to central water tank

before 2,000, in the summer – problems

locals do not feel that there is problem with water scarcity

- Waste water issues
    - Tourkish wastewater treatment – “tholoti agogi” with *stons* for each house “kiriz system”
    - Cheese industry, wasterwater -> to the river

- Changes on wastewater system since 2010; earlier toilet next to home, washing clothes in the river around 1970
- Private well drillings at every farm
- Tsimentoblikes

Villages around Antissa

Lapsadra, small around 5 to 6 families, kampos

Tzithra

Liota, beautiful village

Gavathas, (trifili, fruits-oporpeftika, type of wine grapes) – villagers are fisherment

3 olive presses & 1 cheese industry

People from Antissa

Women/ matriarchal society, never on the agriculte fields

24.08 local festival Liota

Agriculture & Livestock

Goat: cheese, milk

Olive oil productions

Gardening during summer – some of them summer houses

Trifilia for livestock

land; there are available fields

1,000 acres or 100 ha for livestock farming

Olive grooves

Subsidies

Busy period from November to April for livestock farmers

Easy period – in the summer, once per day to take care the animals

Depending on the demand on livestock->work on agriculture

Lapsadra

Rates of field rents in the region 200 € per acre, 0.1 ha

At Lapsadra – 2 bio farmers

Meeting with Participant 7

Prof, Head of Department, University of the Aegean, Department of Environment

Coordination of class visits in the countryside of Lesvos, plant's recognizion.

Interview with Participant 8

President of Agricultural Association Antissa, ex president of Antissa's village

Antissa has around to 1,000 inhabitants (1,140 inhabitants, census 2011). Lapsarda, 10 km away from Antissa, is "rich" in water resources, so agriculture is mainly there. In Antissa, there are in total around to 100.000 olive shrubs. The main plantation is clove and midiki for food for livestock nowadays. In the past, watermelon and potatoes were planted in large quantities. During the World War II, Antissa provided the rest of the island with potatoes. The livestock farming constitutes with sheeps around 90% and 10% with goats. Antissa is popular for the cheese production. A museum with traditional agricultural tools will open in summer 2019 in Antissa. The local festival is on 8th of May. Agrotourism is not popular in the area.

There are both large and small farms equally distributed. The agricultural association of Antissa produces olive oil and feed the wholesaler's market. There are around to 200 members from 30 to 70 years old, 50 of them are active (30-50 years old). The membership is passed from generation to generation. There is no "bio label" branding yet. The best award-olive oil Lesvos constitutes with part of oil from Antissa (Papadelis Babis). The subsidies contribute to half of the income and the rest from selling olive oil. Overall, the region is charecterised like "west" world with young generation to migrate.

Interview with Paticipant 9

Doctor, researcher, artist, poems, sketcher, radio producer, producer of a tv series on local channel

Env Department Aegean at Mytiline work on crème's production form Olive shrubs.

Island's morphology: cultivation according to the soil quality from wheat to grape and olives

14 types of alyssum on Lesvos islany, alyssum lesbiacum can grow on rich nickel soils

Recommended plants for agroforestry vines groves -plum trees-olive shrubs-Peach tree-wild almond -Fig tree - Oak trees Velanidia-*Elaeagnus* -Pomegranates-Not anice-Osier ligaria

Traditional Irrigation system

- Artificial wells
- Declination-> rainwater into artificial wells
- Store water for animals

Traditional Fencing method (See Figure 4.18 Old fencing technique on Lesvos)

- 2 lines with rocks from the region, among them smaller s*tones* and soil
- On top of that some shrubs-woody dried plants from the region
- On top of shrubs

In the region, a field exists with 10 km of this type of fencing.

Acorn production on the island and local architecture

The acorn was used for leather's treatment. During the dictatorship from 1967to 1974, the acorn's harvest was illegal. The farmers cut the trees, because the leaves had been fallen down and due to that the land was difficult to be cultivated.

Asimouki

1 kantari = 14 okades = 60 kg which worth 1 pound

The acorn production shaped the local architecture. The acorn drying took place on the yards of the houses, on cement floor. The storage building of the farmer was equipped with ventilation. The wholesalers bought from each farmer its production and stored them to larger storages at Lutra and Limanakia in Lesvos. Then, they were transported to the port and sold in Mytiline and Geras in Lesvos

The small acorns were used for pig's feed.

Essential's oil production

At Kalloni, there is a laboratory with distillation plant to produce essential oil from oregano, mint etc

Antissa

“Antissa” brings in his mind: vineyards, livestock and large cheese production.

Table 5.2shows working activities of the stakeholders.

5.1.3 Working activities of the stakeholders

Table 5.2 HYDRO2 – Stakeholder list

Interviewee	Institution – working activities
1	Sfontili association
2	director of police office Antissa
3	Local
4	environmental engineer from Lesvos
5	Modusa soc. Association
6	member of Aegilops association, post doc researcher in organic agriculture
7	Farmer at Antissa
8	http://www.enallaktikos.gr/kg15el_antallaktika-diktya_t144_k1102.html
9	Plant nursery with local varieties of pomegranate and figs
10	agronomist with farm at Eressos, TÜV Austria-Hellas
11	Farmer Aghiaso
12	Agricultural Association Antissa, Douroudis Giorgos, ex president of Antissa’s village
13	Filia, Lesvos – rosewarer production
14	Farmer bio, Vatusa
15	Farmer at Antissa
16	new president of dep env science -Ask him for master thesis with statistic data about agrosystems
17	Farmer, preparing a show case biological farm at Mytilene
18	environmental engineer, Water & Wastewater Utility Lesvos
19	Local, Antissa
20	Farmer Aghiaso
21	Farmer at Antissa
22	Aegilops association
23	Fig products, Eressos

24	Lesvos - regional rural development
25	Farmer Asomatos
26	local farmer
27	Teacher
28	Doctor, researcher, artist, poems, sketscher, radio pro-ducer, tv episodes
29	plant nursery in Lesvos with respect to local seeds e.g ahtses (pear)tree
30	prof envir. Sciencet, aromatic plants, interview in the field
31	soc. association Paleokipu - director of prefecture, very active
32	env scientist, puclic servant at Uni Aegean
33	Olive oil press
34	Prof, Head of Department, University of the Aegean, Department of Environment
35	Farmer at Antissa
36	Farmer at Antissa
37	Farmer at Antissa
38	soc. Association – director national bank Lesvos
39	Pellitis association, seeds
40	National Agricultural Research Foundation
41	Young local, café bar of the village
42	Olive oil farmer, biodynamic agriculture Mytiline
43	from Plomari Lesvus at Megaloghori, his olive press- very interesting
44	Mesopotamu -soc. Association – the most active association
45	scientific advisor of AGRISLES project, aegilops assocation, public servant in Lesvos
46	author on local newspaper, active member of the association “Locals of Antissa in Athens *Aghios Ioannis Theologos*”
47	director at health center
48	Flour production, Aghia Paraskevi
49	research-livestock impact on landscape
50	Collection of local seeds, Antissa
51	Local farmer
52	Prof in environmental department
53	Local, filmmaker
54	Post doc researcher on ethnobotalogy, in coordination team of the new research

	center in Lesvos
55	livestock farmer, grazing land next to HYDROUSA's field
56	Engineer, HYDROUSA's partner
57	http://www.enallaktikos.gr/kg15el_antallaktika-diktya_t144_k1102.html
58	gardener, collection of local seeds
59	Farmer at Antissa
60	Geopark
61	Farmer Bio Aronia production

6. SOIL ANALYSIS REPORT

6.1 Data Collection

In this section, the results will be presented of the soil analyses carried out in order to check the suitability of the selected areas for both the Technical Design of the Underground Rainfall Collector and the irrigation project - oregano crops (the results of the soil analyses concerning the cultivation part of the project will not be listed in this section).

The Ground

The Technical Visits to the two alternative application areas of the HYDRO3 system were carried out in person by the Design Engineer. During the visits, soil sampling was carried out in accordance with the sampling protocol followed for the collection of samples for agricultural and rural development. The results will be used both for the dimensioning of the collector and for the installation of the crop and the irrigation system. The holistic approach mentioned in previous chapters is a structural element of the success of this research. The general sampling protocol is outlined below.

Soil sampling protocol

Macroscopic visual inspection of soil uniformity (differences in color, vegetation, landscape, inclination, rocks, etc.). For a Uniform soil, collection of samples is done according to Figure 6.1.

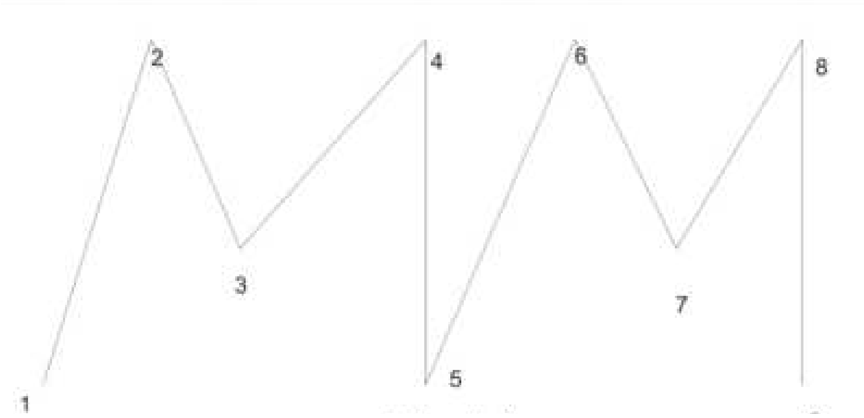

Figure 6.1 Uniform field

If the field is not uniform, i.e. it consists of different soil types (another color), or is at a gradient or there is a difference in plant growth, we divide the field into uniform soil sections and collect the samples according to Figure 6.2.

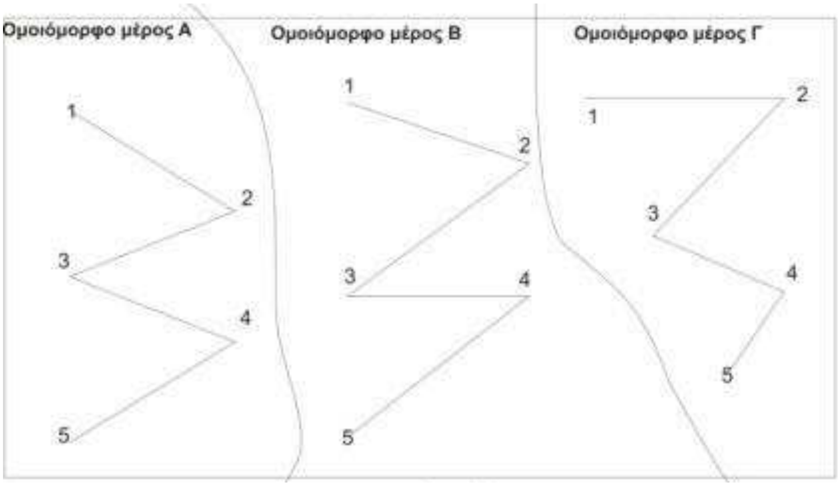

Figure 6.2 Non-uniform field

Procedure

1. Selection of points for sample collection
2. Removal of surface plants, leaf residues and sampling area cleaning
3. Sampling is done by a special sampling tool or a shovel shown in Figure 6.3

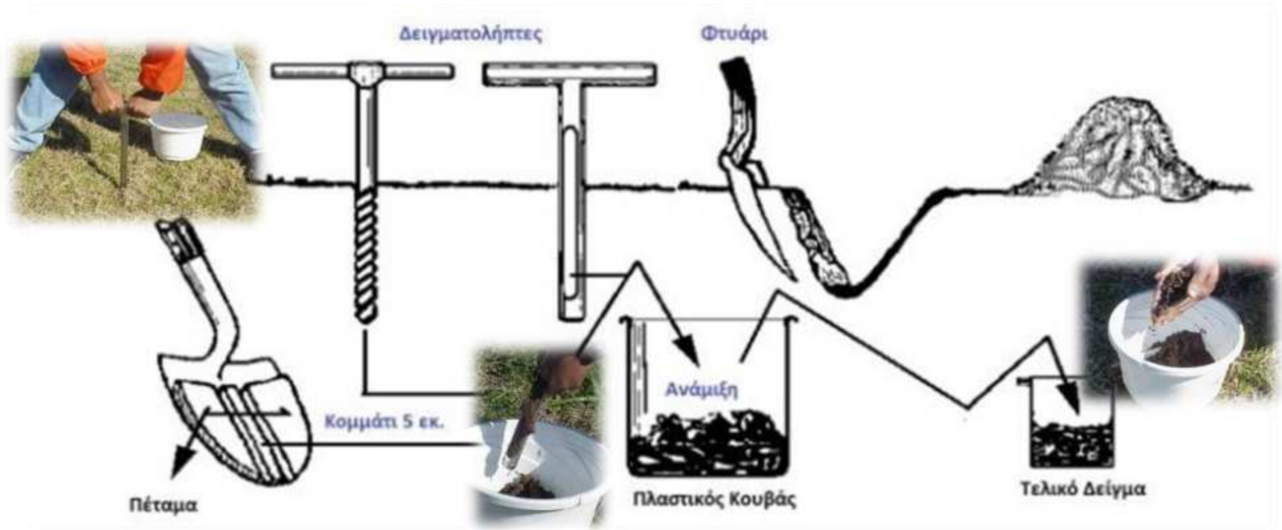

Figure 6.3 Schematic representation of the sampling procedure

4. The soil from all points and from the same depth of collection is placed in a bucket or deep tray and is well mixed until it becomes uniform
5. Any roots, stones, leaves, etc. are removed
6. The already mixed and homogeneous sample is placed in a plastic bag and the final sample (weighing approximately 500-600 g (dry) or 1 kg (liquid)) is obtained
7. The sample data is noted (location, code, date, etc.)

Caution! Avoid mixing samples from different plots or different depths

Sampling depth:

Vegetables and large crops: sample at a depth of 0-30 cm.

Trees or vines: usually two samples at a depth of 0-30 and 30-60 cm, and for forestry trees at 90-100 cm.

Greenhouses: sampling should be done from a depth of 0-15 or 0-20 cm and circumferentially at 15-20 cm from the drippers.

Additional sampling instructions

The soil must be easy to rub so that the individual samples can be mixed with relative ease

In crops of **horticultural, vegetable, floricultural specimens,** the sample should always be collected from the planting lines at the watering points, about 10 cm from the trunk of the plant, neither too close to the trunk, so as not to injure it, nor very close to the joint groove where there is accumulation of salts

In tree crops sampling is done under the tree

No watering or fertilizing on **greenhouse crops** on the day of sampling

In all cases sampling should not be carried out after the addition of organic substances (manure, greenery, etc.) or fertilizing or disinfecting, especially with phosphate or potassium fertilizers

Avoid collecting samples near streets, stables, grooves or sites where corrosion is observed

Avoid collecting samples after heavy rainfall

The soil analyses which will be considered for the design decision making, dimensioning of the Underground Collector of rainfall water focus on the determination and knowledge:

The **hydraulic characteristics** of the soil (soil moisture, specific weight, saturation water (SP), permanent wilting point (PWP), water capacity (FC), available water (%), porosity),

Of its **mechanical composition** (percentage in sand, sludge, clay) and

Of its **physicochemical properties** (pH, Electrical Conductivity, Total and Active CaCO3, Organic matter)

Sampling depth is 0-30 cm. This is, as mentioned above, for a shallow Underground Collector

The laboratory analytical methods used to extract the results are the most appropriate analytical protocols (a detailed presentation of the analytical methods followed is a sterile redundancy for this Technical Report).

6.2 Soil analysis results

6.2.1 Lesvos

The field of Agroforestry was divided into two main areas, 0.7 ha area (5 sampling points – A, B, C, D, E) and 0.3 ha area (1 sampling point, H). Soil samples were collected from each point at 30, 60 and 90 cm depths. The soil samples were analyzed for different parameters and results shown in Figures 6.4 and 6.5:

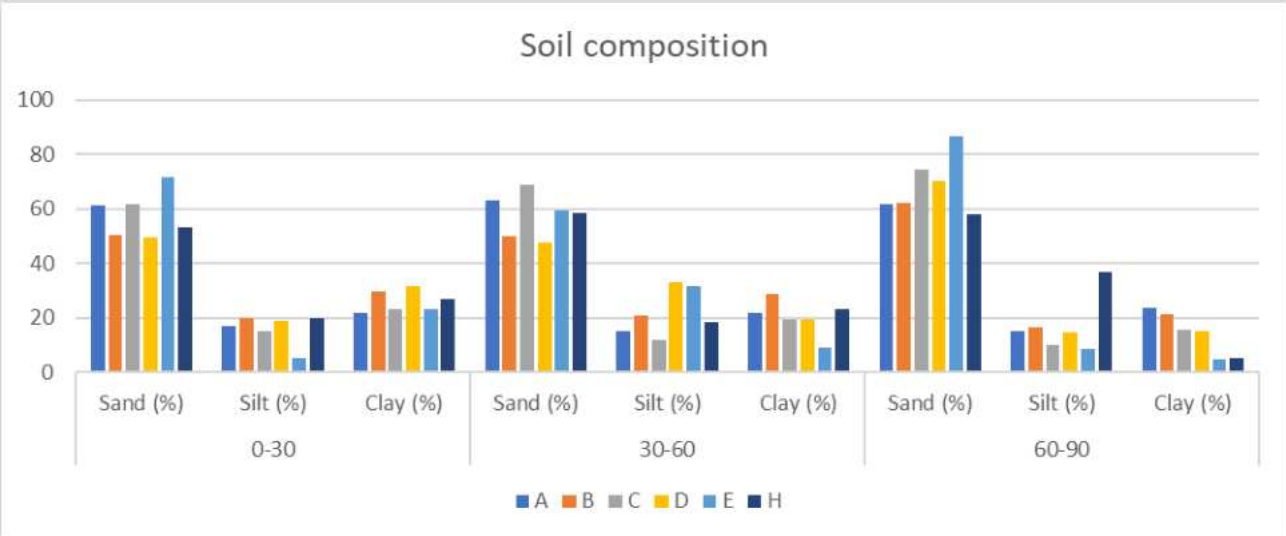

Figure 6.4 Physical composition of soil samples

Figure 6.5 Chemical properties of the soils in Lesvos

6.2.2 Mykonos

The collected results from the two regions are presented below in Tables 6.1 to 6.6.

Table 6.1 Hydraulic Characteristics of the Soil - "Skafes" - Lia

Hydraulic Characteristics of the Soil - "Skafes"		
Ground moisture	**1.01**	%
Apparent Specific Weight	**1.18**	g/cm3
Percentage of Saturation Water (SP)	**39.79**	%
Permanent Wilting Point (PWP)	**9.95**	%
Water Capacity	**30.41**	%
Water Holding Capacity (FC)	**19.89**	%
Available Water	**9.95**	%

Table 6.2 Mechanical Composition of the Soil - "Skafes" - Lia

Mechanical Composition of the Soil - "Skafes" - Lia

PARAMETER	RESULT (%)	METHOD
Sand	**79.60**	Bouyoucos
Silt	**15.76**	
Clay	**4.65**	

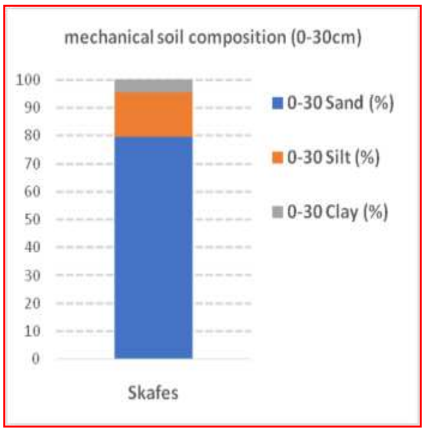

Table 6.3 Physico-chemical properties of Soil - "Skafes" - Lia

Physico-chemical properties of Soil - "Skafes" – Lia

PARAMETER	VALUE	UNIT	METHOD
pH	**6.94**	~	Saturation Water
Elec. Conductivity	**653.00**	μS/cm	Saturation Water
Total $CaCO_3$	**0.29**	%	Volumetric
Active $CaCO_3$	**0.00**	%	$C_2O_4(NH_4)_2$
Organic matter	**0.87**	%	Wet oxidation

Table 6.4 Hydraulic Characteristics of the Soil - "Ampelokipi" - Ano Mera

Hydraulic Characteristics of the Soil - "Ampelokipi"

Ground Moisture	**1.01**	%
Apparent Specific Weight	**1.42**	g/cm3
Percentage of Saturation Water (SP)	**34.34**	%
Permanent Wilt Point (PWP)	**8.58**	%
Water Capacity	**27.14**	%
Water Holding Capacity (FC)	**17.17**	%
Available Water	**8.58**	%

Table 6.5 Mechanical Composition of the Soil - "Ampelokipi" - Ano Mera

Mechanical Composition of the Soil - "Ampelokipi"

PARAMETER	RESULT (%)	METHOD
Sand	**75.96**	
Silt	**16.16**	Bouyoucos
Clay	**7.88**	

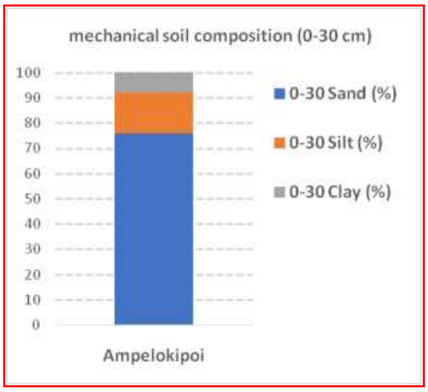

Table 6.6 Physico-chemical properties of the Soil - "Ampelokipi" - Ano Mera

Physico-chemical properties of the Soil - "Ampelokipi"

PARAMETER	VALUE	UNIT	METHOD
pH	**7.42**	~	Saturation Water
Elec. Conductivity	**291.00**	μS/cm	Saturation Water
Total $CaCO_3$	**0.16**	%	Volumetric
Active $CaCO_3$	**0.00**	%	$C_2O_4(NH_4)_2$
Organic matter	**0.90**	%	Wet Oxidation

Remarks:

- Soils, according to their mechanical analysis, are characterized by a high percentage of sand (Sandy - light soils). In the area of Skafes there is a lower percentage of the clay composition-component than in Ampelokipi. By comparison, the granulometric composition presents the soil in Ampelokipi as coarser than in Skafes. Therefore, one (Skafes) could be categorized as **LS - LOAMY SAND**, while the other (Ampelokipi) as **SAND LOAMY**
- Both soils have little water retention capacity (and therefore nutritional). They exhibit the ability to quickly drain (suitable for the application of a collector)

In addition and expanding in terms of crop prospects (oregano), they are judged as suitable for their mechanical and hydraulic characteristics, provided they are rationally fertilized (generally poor soils) and small and frequent adequate doses of irrigation water are applied (for more details on the nutritional content see below - parallel actions - preliminary agro-technical analysis of the irrigation system & cultivation).

6.2.3 TINOS

The fields of Ecolodge of Tinos (ELT) was divided into different areas based on the type of cultivation; Vegetables, Grapes, Herbs, etc. The soil samples were taken at 30 cm depth, and analyzed for different parameters and results are shown in Figures 6.6 and 6.7.

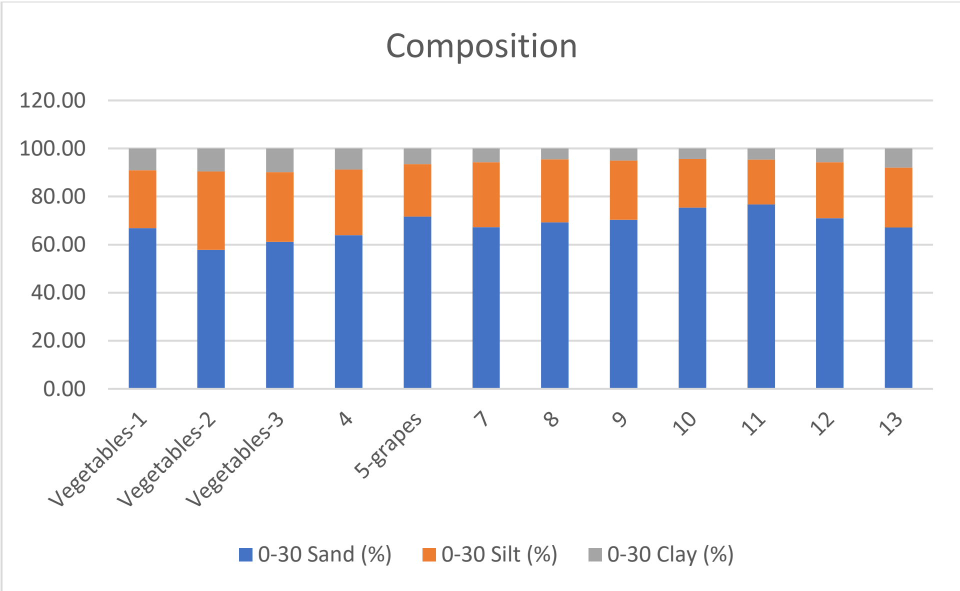

Figure 6.6 Soil composition of different cultivation areas at ELT

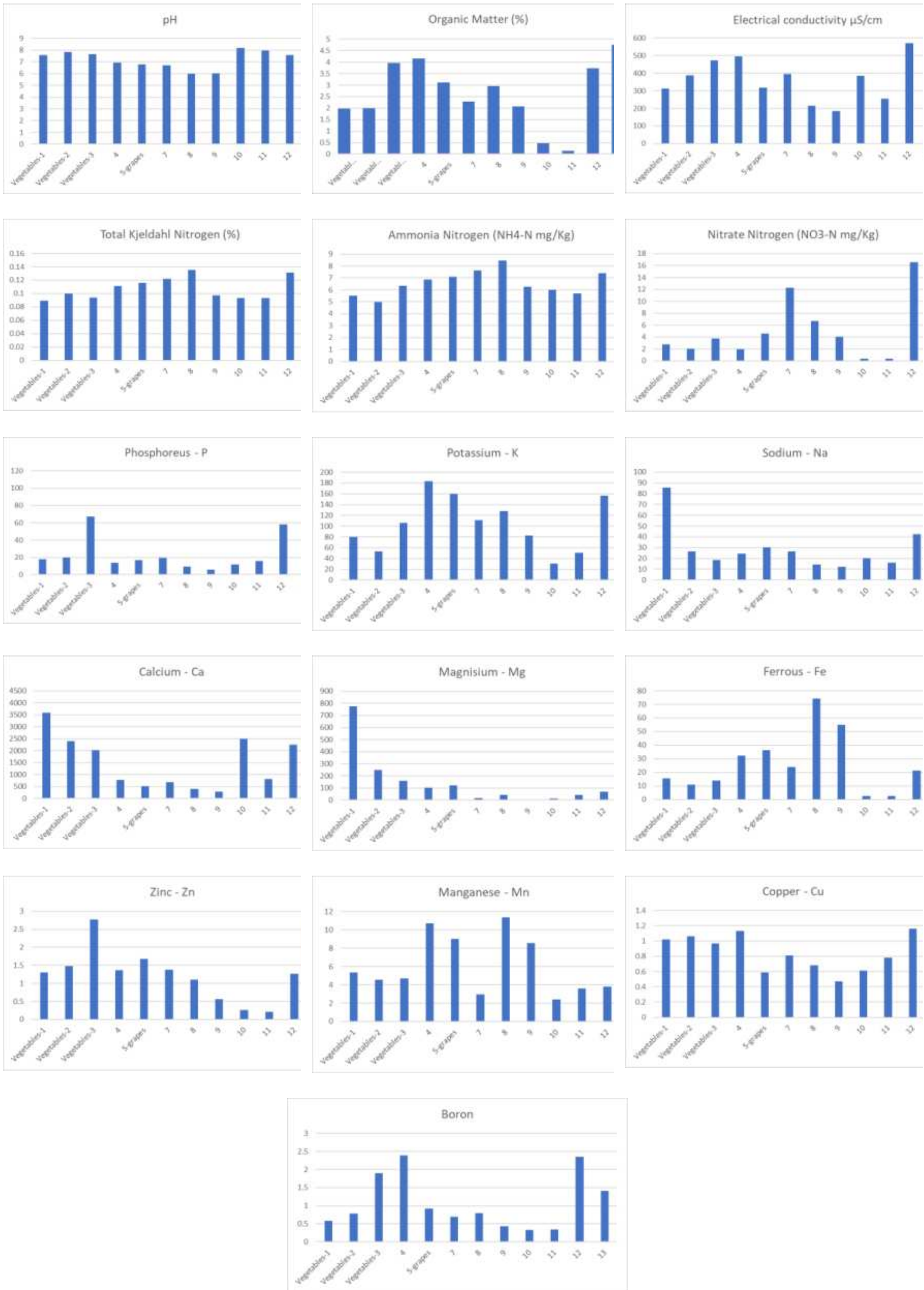

Figure 6.7 Chemical properties of the soils in ELT

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8. ANNEX- CATALOGUE OF SELECTED PLANTS

Table 8.1 Catalogue of selected plants

SPECIES	**YIELD**	**MARKET PRICE**
Albizia julibrissin	N/A	Pot price[1]
Castanea sativa (Chestnut)	20-50 kg/tree/year[6]	1.70-2.70 €/kg (selling price as a producer)[2]
Citrus aurantifolia (Key lime)	20 kg/tree[6]	4.35 €/kg https://www.tridge.com/products
Citrus Limon (Lemon)	50 kg/tree/year	1.20-1.40 €/kg[3]
Citrus maxima (Pomelo)	20 kg/ tree/year[6]	1.27 €/kg
Citrus reticulate	40 kg/ tree/year[6]	0.30-0.33 €/kg (selling price as a producer)[4]
Corylus maxima	5-6 kg dry weight tree/year[6]	1.80-2.00 €/kg (selling price as a producer)[5]
Elaeagnus multiflora (Cherry)	20-30 kg/tree/year[65]	1.5-2.50 €/kg (selling price as a producer)[6]
Eriobotrya japonica (Loquat)	30 kg/tree/year[65]	1.5 €/kg (selling price as a producer)[7]
Ficus carica (Fig)	100 kg/fresh per tree per year[5]	1.15-2.15 €/kg (selling price as a producer)[8]
Hippophae rhamnoides (Sea Buckthorn)	6- 7 kg/tree[9]	3 €/kg (selling price as a producer)[10]
Laurus nobilis (Laurel)	150 kg dry leaves/ha[11]	15-20 €/kg[12]
Lavandula angustifolia (True Lavender)	100 kg/acre the 1st year[13] 7-10 kg essential oil[14]	11.5 €/kg [15]

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[1] https://horomidis.gr/product/albizia-julibrissin-akakia-konleos/
[2] https://www.agrotypos.gr/kalliergeies/karpoi-me-kelyfoskalliergeies/se-kala-epipeda-fetos-oi-times-paragogou-gia-karydi-kai
[3] https://www.okaa.gr/gr/nea-kai-anakoinoseis/statistika-deltia-timon/
[4] https://www.agrotypos.gr/kalliergeies/esperidoeidi/mantarini-klimentini-xekinoun-se-liges-imeres-oi-protes-kopes-simantika https://www.pellanews.gr/%CE%B1%CE%B3%CF%81%CE%BF%CF%84%CE%B9%CE%BA%CE%AC/%CF%83%CF%84%CE%B1-30-%CE%BB%CE%B5%CF%80%CF%84%CE%AC-%CF%84%CE%BF-%CE%BA%CE%B9%CE%BB%CF%8C-%CF%84%CE%BF-%CE%BC%CE%B1%CE%BD%CF%84%CE%B1%CF%81%CE%AF%CE%BD%CE%B9-%CF%83%CE%B5-%CF%84%CE%B9%CE%BC%CE%AE-%CF%80%CE%B1%CF%81%CE%B1%CE%B3%CF%89%CE%B3%CE%BF%CF%8D-5
[5] https://www.epixeiro.gr/article/3451
[6] https://www.okaa.gr/gr/nea-kai-anakoinoseis/statistika-deltia-timon/
[7] https://almopia.wordpress.com/2011/05/19/%CE%B5%CF%80%CE%B9%CE%BC%CE%AD%CE%BD%CE%B5%CE%B9-%CE%B2%CE%B9%CE%BF%CE%BB%CE%BF%CE%B3%CE%B9%CE%BA%CE%AC-%CF%84%CE%BF-%CE%BC%CE%BF%CF%8D%CF%83%CE%BC%CE%BF%CF%85%CE%BB%CE%BF/
[8] https://www.agrocapital.gr/Category/Products/Article/37907/oi-fetines-times-gia-xiro-kai-biologiko-syko
[9] https://www.epixeiro.gr/article/13320
[10] http://agroepidotiseis.blogspot.com/2013/10/blog-post_28.html
[11] https://www.capitalinvest.gr/index.php/ependyseis/agrotikes-ependyseis/89-kaliergia-dafni
[12] https://www.capitalinvest.gr/index.php/ependyseis/agrotikes-ependyseis/89-kaliergia-dafni
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[15] https://www.capitalinvest.gr/index.php/ependyseis/agrotikes-ependyseis/90-rigani-menta-levalnta

Lycium barbarum (Gogi berry)	1,500 kg fresh nuts/acre 700-800 dried[16]	6-7 €/kg (selling price as a producer)[3]
Malus domestica (Apples)	30-60 kg/tree/year [5]	0.80-1.20 €/kg (selling price as a producer)[17]
Mentha spicata	400-600 kg dry 4-7 kg/acre	9.78 €/kg
Moringa oleifera (Moringa)	0.7 tn/acre (3rd year) Not Greek reference[18]	5.88 €/kg
Morus nigra / alba	25 kg per tree[19] 250 kg /tree/year (5-6 year after is planted)[20]	7 l pot 18 € 10 l pot 25 € 9-21 € dried [21]
myrtus communis	1,000 kg/acre	4-5 €/kg
Olea Europea (Olives)	20 kg/ tree/year[61]	1.5[22]
Olea Oleaster (Wild Olives)	20 kg/ tree/year[61]	(wild olive oil) 14.50-17.50+VAT (selling price as a producer)[23]
Persea americana (Avocado)	40-50 kg/ tree/year[61]	5 €/kg
Pimpinella anisum	0.60-1.20 kg dry weight per year [1]	800-900 €/acre (profit)[24]
Prunus Avium	20-30 kg/ tree/year[61]	1.5-2.5 € [25]
Prunus dulcis (Almond)	2-20 kg dry weight/tree/year[1]	2.5-3 €[26]
Punica granatum (Pomegranate)	2,500-3,000 kg/acre for pomegranate of 8-10 years)[27]	1,200 € per acre[28]
Ribes Nigrum	4.5 kg/bush per year[29] Not Greek reference	1.50-1.60 €/kg (selling price as a producer)[30]
Ribes Rubrum	3-4 kg/tree[31]	3,000 €/acre (as income)[32]
Ribes Sanguineum	0.6-1 kg/acre[33] (not Greek reference)	10.5 €/kg

[16] http://agroepidotiseis.blogspot.com/2013/10/blog-post_28.html
[17] https://www.okaa.gr/gr/nea-kai-anakoinoseis/statistika-deltia-timon/
[18] https://medium.com/@dpmaharshi/tips-to-maximize-moringa-seed-oil-yield-74171fa5fcc7
[19] http://agr.uth.gr/wp-content/uploads/2019/04/simioseis_eidikis.pdf
[20] https://rsrub.ru/el/elementy/chem-polezna-chernaya-shelkovica-vyrashchivanie-shelkovicy-chernoi-na-dachnom.html
[21] http://agr.uth.gr/wp-content/uploads/2019/04/simioseis_eidikis.pdf
[22] https://www.ypaithros.gr/elia-beltiomenous-ogkous-sygkratimenes-times-efere-2019-ellina-paragogo/
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[27] https://www.epixeiro.gr/article/13320
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[31] https://www.huffingtonpost.gr/kassandros-gatsios/-_2074_b_8347042.html
[32] https://www.eirinika.gr/article/26621/serres-mehri-3000-eyro-kerdos-apo-tin-kalliergeia-fragkostafylloy-vatomoyroy-ti-leei
[33] https://encyclopedia2.thefreedictionary.com/Ribes

Ribes uva-cripsa (Gooseberry)	5 kg/tree/year[6]	2-3 €/kg[34]
Rubus fruticosus (Blabkberry)	500-1,000 kg/acre per year[35]	5 € package of 120 gr 1,600 €/acre (profit)[36]
Sorbaronia mitschurinii (Black chokeberry)	1,300-1,800 kg/acre[37]	1,000 €/acre (income)[38]
origanum vulgare	97-108 kg/acre	1.8-2.3€/kg (selling price as a producer)[39]
Pimpinella anisum (Seeds)	0.6-1.2 dry weight as nuts	500 € acre per year[40]
Zea Mays (seeds)	1,200-1,800 kg per acre[41]	0.17-0.18 €/kg (selling price as a producer)[42]
Echinacea (seeds)	400 kg per acre[43]	12 €/kg[44]
Melissa officinalis (seeds)	1,200 kg fresh 400 kg dry[45]	4-6 €/kg[46]
Valeriana officinalis (seeds)	400 kg dry/acre	1000 € per acre[47] 18 €/kg [48]
Agave americana (American Aloe)	12-16 leaves the first year[49]	2.24 €/kg
Juniperus communis (Juniper)	1.2 t/ha/year	50.4 €/kg
Thymbra	200 kg dry leaves and flowers (2nd year)[50]	3 €/kg 2,000 €/acre/year (as income)
Quercus ithaburensis (Tabor Oak)	N/A	N/A
Betula pendula (Silver Birch)	N/A	58 €/kg
Sequoiadendron giganteum (Sequoia)	11,000 cones/tree[51]	N/A

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[35] https://agrosimvoulos.gr/kalliergeia-batomouron/
[36] https://www.symagro.com/vatomoura-kalliergeia/
[37] http://agroepidotiseis.blogspot.com/2013/10/blog-post_28.html
[38] http://agroepidotiseis.blogspot.com/2013/10/blog-post_28.html
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[42] https://www.ypaithros.gr/kalampoki-19-lepta-times-stin-peloponniso-15-lepta-boreia-ellada/
[43] http://superfoodshellas.blogspot.com/2013/05/blog-post_12.html
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[45] https://agrosimvoulos.gr/kalliergeia-melissoxortou/
[46] https://agrosimvoulos.gr/kalliergeia-melissoxortou/
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[49] https://www.ftiaxno.gr/2014/01/kalliergeia-athanatou-kai-oi-xriseis-tou.html
[50]https://agrosimvoulos.gr/%ce%b1%cf%81%cf%89%ce%bc%ce%b1%cf%84%ce%b9%ce%ba%ce%ac-%ce%ba%ce%b1%ce%b9-%cf%86%ce%b1%cf%81%ce%bc%ce%b1%ce%ba%ce%b5%cf%85%cf%84%ce%b9%ce%ba%ce%ac-%cf%86%cf%85%cf%84%ce%ac/
[51]https://el.wikipedia.org/wiki/%CE%A3%CE%B5%CE%BA%CE%BF%CF%8A%CE%AC%CE%B4%CE%B5%CE%BD%CE%B4%CF%81%CE%BF_%CF%84%CE%BF_%CE%B3%CE%B9%CE%B3%CE%B1%CE%BD%CF%84%CE%B9%CE%B1%CE%AF%CE%BF

Tilia tomentosa (Silver linden)	Ornamental plant	(Ornamental plant)
Arbutus unedo (Strawberry)	1st year: 3 kg 2nd year 7-20 kg 3rd year 7-20 kg Green house >25 kg[1]	3.5 €/kg (selling price as a producer)[52]
Rubus idaeus L (Red berry)	4-5 kg[1] 800-1,000 kg per acre[53]	5.5-8 €/kg (selling price as a producer)[54]
Nerium oleander (Oleander)	Ornamental plant	Ornamental plant
Ananas comosus L. (Pineapple)	4,000-7,000 kg per acre[55]	0.67 €/kg
Carica papaya L. (Papaya)	60-90 kg/tree[56]	0.80-1.50 €/kg
Curcuma longa L. (Common turmeric)	16 t/ha	4.58 €/kg
Musa acuminata Colla (Edible banana)	300-400 bananas per bunch	0.70-1.15 €/kg[57]
Panax ginseng (Asian. Chinese or Korean ginseng)	380 kg dry roots/ha	246 €/kg
Passiflora edulis Sims (Purple passion fruit)	150-250 kg fruits per acre[58]	42.56 €/kg
Zingiber officinale Roscoe (Ginger)	2,000-3,000 kg per acre with no irrigation 4,000 kg per acre irrigated[59]	5.14 €/kg

Herbs (general price): 150-400 €/acre[60], for essential oil up to 1200 €/acre

[52] https://www.ypaithros.gr/%CF%86%CF%81%CE%AC%CE%BF%CF%85%CE%BB%CE%B1-%CE%B3%CE%BB%CF%85%CE%BA%CE%AD%CF%82-%CF%84%CE%B9%CE%BC%CE%AD%CF%82-%CE%BA%CE%B1%CE%B9-%CE%B1%CF%80%CE%BF%CE%B4%CF%8C%CF%83%CE%B5%CE%B9%CF%82-%CE%BC%CE%AD/

[53] https://www.e-forologia.gr/cms/viewContents.aspx?id=171329

[54] https://www.e-forologia.gr/cms/viewContents.aspx?id=171329

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[56] https://services.agrotypos.gr/eshop/index.asp?mod=eshop_item&cID=62&pID=63277

[57] https://www.okaa.gr/gr/nea-kai-anakoinoseis/statistika-deltia-timon/

[58] https://www.thessalikigi.gr/enot-news/7861
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[59] https://agrosimvoulos.gr/kalliergia-ginger-kalliergitikes-texnikes/

[60] https://www.patt.gov.gr/site/attachments2/4896_anastopoulos.pdf