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1 Introduction

The present Document constitutes the deliverable 3.1.1. “Study Ex-ante analysis of olive growing best practices (Document)” of the WP 3 “Studies” of the project “AGROQuality: Towards a Common Quality Control and food chain traceability system for the Greek – Italian primary sector of activity”. TEI of Epirus, the leader partner (LP) of Agroquality, was in response to implement the corresponding this study for the Region of Epirus.

2 The olive world[1]

The origin of the olive tree is lost in time, coinciding and mingling with the expansion of the Mediterranean civilisations which for centuries governed the destiny of mankind and left their imprint on Western culture.

Olive leaf fossils have been found in Pliocene deposits at Mongardino in Italy. Fossilised remains have been discovered in strata from the Upper Paleolithic at the Relilai snail hatchery in North Africa, and pieces of wild olive trees and stones have been uncovered in excavations of the Chalcolithic period and the Bronze Age in Spain. The existence of the olive tree therefore dates back to the twelfth millennium BC.

The wild olive tree originated in Asia Minor where it is extremely abundant and grows in thick forests. It appears to have spread from Syria to Greece via Anatolia (De Candolle, 1883) although other hypotheses point to lower Egypt, Nubia, Ethiopia, the Atlas Mountains or certain areas of Europe as its source area. Caruso for that reason believed it to be indigenous to the entire Mediterranean Basin and considers Asia Minor to have been the birthplace of the cultivated olive some six millennia ago. The Assyrians and Babylonians were the only ancient civilisations in the area who were not familiar with the olive tree.

Taking the area that extends from the southern Caucasus to the Iranian plateau and the Mediterranean coasts of Syria and Palestine (Acerbo) to be the original home of the olive tree, its cultivation developed considerably in these last two regions, spreading from there to the island of Cyprus and on towards Anatolia or from the island of Crete towards Egypt.

In the 16th century BC the Phoenicians started disseminating the olive throughout the Greek isles, later introducing it to the Greek mainland between the 14th and 12th centuries BC where its cultivation increased and gained great importance in the 4th century BC when Solon issued decrees regulating olive planting.

From the 6th century BC onwards, the olive spread throughout the Mediterranean countries reaching Tripoli, Tunis and the island of Sicily. From there, it moved to southern Italy. Presto, however, maintained that the olive tree in Italy dates back to three centuries before the fall of Troy (1200 BC). Another Roman annalist (Penestrello) defends the traditional view that the first olive tree was brought to Italy during the reign of Lucius Tarquinius Priscus the Elder (616 - 578 BC), possibly from Tripoli or

[1] The information provided in this chapter was provided by the International Olive Council (http://www.internationaloliveoil.org/web/aa-ingles/oliveWorld/olivo.html)

Gabes (Tunisia). Cultivation moved upwards from south to north, from Calabria to Liguria. When the Romans arrived in North Africa, the Berbers knew how to graft wild olives and had really developed its cultivation throughout the territories they occupied.

The Romans continued the expansion of the olive tree to the countries bordering the Mediterranean, using it as a peaceful weapon in their conquests to settle the people. It was introduced in Marseilles around 600 BC and spread from there to the whole of Gaul. The olive tree made its appearance in Sardinia in Roman times, while in Corsica it is said to have been brought by the Genoese after the fall of the Roman Empire.

Olive growing was introduced into Spain during the maritime domination of the Phoenicians (1050 BC) but did not develop to a noteworthy extent until the arrival of Scipio (212 BC) and Roman rule (45 BC). After the third Punic War, olives occupied a large stretch of the Baetica valley and spread towards the central and Mediterranean coastal areas of the Iberian Penisula including Portugal. The Arabs brought their varieties with them to the south of Spain and influenced the spread of cultivation so much that the Spanish words for olive (aceituna), oil (aceite), and wild olive tree (acebuche) and the Portuguese words for olive (azeitona) and for olive oil (azeite), have Arabic roots.

With the discovery of America (1492) olive farming spread beyond its Mediterranean confines. The first olive trees were carried from Seville to the West Indies and later to the American Continent. By 1560 olive groves were being cultivated in Mexico, then later in Peru, California, Chile and Argentina, where one of the plants brought over during the Conquest - the old Arauco olive tree - lives to this day.

In more modern times the olive tree has continued to spread outside the Mediterranean and today is farmed in places as far removed from its origins as southern Africa, Australia, Japan and China. As Duhamel said, "the Mediterranean ends where the olive tree no longer grows", which can be capped by saying that "There where the sun permits, the olive tree takes root and gains ground".

3 Bibliography of olive tree artificial cultivation methods in the Greek areas

3.1 INTRODUCTION

3.1.1 The significance of the olive tree cultivation for Greece

In Greece, the olive has been dominant since the ancient times. As a symbol of knowledge, wisdom, abundance, peace, health, strength and beauty, it has been worshipped for thousands of years. The olive tree constitutes a vital part of a huge cultural heritage, full of legends, traditions and religious rituals, inextricably linked with the efflorescence, harvesting, as well as the olive oil production.

Most surveys concerning its origin exhibit ambiguous results, however they all conclude to the fact that its deeper origins derive from the wider Mediterranean area. Anagnostopoulos (1951) has argued that the homeland of the olive is Crete, based on findings from excavations in Knossos.

Nowadays, it is the most significant tree cultivation in our country, as it occupies approximately 15% of the cultivated land and 78% of the tree planted land. A very large number of the rural population of the country is involved in olive tree growing and processing, while in many areas, olive oil is the farmers' sole source of income. Also, 2,500 oil mills, around 300 oil standardization companies and 80 table olive processing factories are active in the industry of olive oil product processing and trading. The olive, along with its products, occupies 2% of the total national costs and 15% of the national rural income.

Greece is the third country in the world (following Spain and Italy) in olive oil production. The olive grows in 50 out of 54 prefectures of the country and it is estimated that there are around 160 millions of olive trees, which yield 2, 5 million tons of olive fruits. They, in turn, yield around 390,000 tons of olive oil and 100,000 tons of table (edible) olives of various categories (Greek Statistics, 2006). Last, around 25,000 tons of olive pomace oil is produced by the processing of the olive residue.

In relation to the facts of 1985 (Sfakiotakis, 1987), there has been an increase in the number of olive oil trees by 25% (from 120 to 160 million), whilst the production was increased from 1, 7 tons to 2, 5 tons (30% increase).

With regard to the prefecture of Arta, the olive crop features an important part of the agricultural activity. Around 6,000 producers are involved in the olive cropping. In the prefecture, more than

1,000,000 olive trees are cultivated, which take up 55,000 stremmas of arable land, especially in the semi-mountainous areas, and produce around 15,000 tons of fruits annually. This quantity is mainly used for the production of edible olives and secondly for olive oil production (especially the fruits of low market value as edible olives due to their size). This quantity derives mainly from two large-fruited cultivars, the most important being firstly the 'Konservolia' and secondly the 'Kalamon' olive, the latter being mainly cultivated on the Arachthos river sides, where the high atmospheric humidity makes cropping suitable.

3.1.2 The most principal olive cultivars grown in Greece

The selection of the adequate olive cultivar for the plantation of a new olive grove is probably the most important factor which will make the crop successful in the production of olive oil products both quantity and quality-wise. This happens because the cultivar, being the genetic material, determines the possibilities both in productivity and product quality, however always in combination with the climatic conditions. The selection of the proper olive cultivar is of great importance, as it can assure the entrance of the product within the products certified by the European Union or even better succeed better prices with the Products of Designated Origin (PDO) and the Products of Protected Geographical Indication (PGI) (Vemos and Vakhamides, 2009).

Greek cultivars which have been described surpass the total amount of 72, while according to the national lists, they surpass the number of 40. As for the non-Greek varieties, only a few are harvested in Greece nowadays. The olive cultivars are characterized according to the purpose they are used as: table olives, olive-oil olives and olives of mixed use.

Table 1:The most important olive cultivars

Cultivar	**Fruit size**	**Other names**	**Main growing areas**
Table olives			
Konservolia	Large	Amphissis, Artas, Volos,Pilio,Patras ,Chondrolia, etc	Main and Western Greece, Chalkidiki,
Kalamon	Large	Kalamatiani, Aetonihia,	Peloponnese

		Korakolia, etc	
Chalkidikis	Large	Gaidourolia	Crete
Olive-oil olives			
Koroneiki	Small	Lianolia, Crete, Olive-oil, Psilolia, Koronia	Peloponnese, Crete, Western Greece
Mastoides	Small	Athinolia, Tsounati, Matsolia, Mouratolia	Peloponnese, Crete
Lianolia Kerkiras	Small	Korfolia, Merolia, Prevezana, Striftolia, Souvlolia	Corfu, Kefalonia, Zante, Preveza and Thesprotia
Koutsourelia	Small	Patrini, Patrinia, Olive-oil olive, Lianolia	Korinthia, Achaia, Lakonia and Etoloakarnania
Adramittini	Medium	Adramittiani, Aivaliotiki, Fragolia	Lesvos
Agouromanakolia	Medium	Agouromanako, Agouromanaki	Argolida, Korinthia, Arkadia
Dual purpose olives			
Megaritiki	Medium	Chondrolia, Perahoritiki, Vovoditiki, Aegina	Attiki, Viotia,
Throumbolia	Medium	Askouda, Thassitiki, Ntopia, Chondrolia	Islands of the Aegean Sea, Attiki, Evia and Crete
Kothreiki	Large	Corinthiaki, Glikomanaki, Manaki, Manakolia	Argolida, Korinthia, Arkadia, Fokida and Fthiotida
Valanolia	Medium	Mpolanolia , Kolovi, Mytilenia, Milolia olive	Lesvos, Chios

3.1.3 Selection criteria of olive cultivars

The main criteria for the selection of a cultivar are productivity (fruit efficiency per tree or per stremma and % fruit oil efficiency) and fruit and oil quality.

Also, the commercial criterion of cultivar (either for olive oil or table olives), which is determined by the quality and the consumer's preferences, is another important selection criterion. Another criterion which should be taken into account is the intensity of cultivar, as it determines the size of the tree, the

planting density and the possibility of intense planting (20-40 trees per stremma) or super-intense planting (140-200 trees/ stremma).

The environment adaptation (soil, climatic conditions) for the achievement of maximum performances (in quality and quantity) should be taken into serious consideration, too. In general, the olive can adapt itself to various soil types. However, soil rich in calcium and boron are more efficient. Salts and especially sodium chloride need to be less than 1 g/L. There are however cultivars which are harvested under specific requirements, such as 'Konservolia', 'Throumbolia', 'Vasilikada', 'Valanolia' and especially 'Kalamon', which requires a loam texture soil with an excellent level of pH (7).

The adaptation to various climatic conditions, such as the resistance at low temperatures, the requirements in cold temperatures for the flower bud and flower differentiation, varies among the cultivars. The 'Amphissis', 'Chalikidikis', 'Throubolia' and the Spanish 'Sevillano' cultivars are demanding in low temperatures.

The 'Koroneiki' , 'Kothreiki' , 'Amigdalolia' and 'Gaidourelia' cultivars are drought and warm-dry air tolerant. 'Kalamon' produces better in areas high in relative humidity in the atmosphere, while its harvest becomes problematic in dry climates. On the contrary, 'Koutsourelia' is problematic in environments high in relative humidity (leaf spot infestations). Table 2 displays measurements of low tolerance resistance in various varieties. Varieties illustrating the indicator 3 are more tolerant.

Table 2: Varieties tolerant in low temperatures (Indicator 3 shows the most tolerant ones), (Source: Vemos and Vahamides, 2009)

Greek cultivars		**Non-Greek cultivars**	
Olive-oil olives	**Table olives**	**Olive-oil olives**	**Table olives**
Mastoides (3)	Karidolia (3)	Arbequina(3)	San Francesco(3)
Black olive(3)	Kothreiki (3)	Picual(3)	Manzanilla(2.5)
Agouromanakolia(3)	Vasilikada (3)	Leccino(2.5)	Mission(2.5)
Valanolia(2.5)	Kalamon (2)	Frantoio(2)	
Lianolia of Corfu(2.5)	Konservolia(2)		
Megara(2.5)			
Adramittini(2.5)			

Resistance to diseases and enemies, even if not thoroughly studied, is an important factor when it comes to the selection of cultivar. Thus, 'Koroneiki' is sensitive to Dacus and fireblight (cancerosis).

Self-fruitfulness and self-fertility of cultivars. It is known that most Greek cultivars are self-fertile (eg 'Koroneiki'); however, there are some partially self-infertile ones, such as 'Kalamon', 'Amphissis', 'Throumbolia' and 'Megaritiki'. This means that in order for a good pollination and production of these varieties to exist, self-pollinating cultivars, suitable for pollination of the main ones, should exist in the same piece of land. Although there is not so much evidence concerning the self-infertility and adequate pollinators of the Greek cultivars, however, data with the adequate pollinators for 4 partially self-infertile varieties is displayed in Table 3.

Table 3: Indicative list of pollinators for the equivalent main cultivated cultivars. (Source: Vemos and Vakhamides, 2009)

Main Cultivar	Pollinators
Chalikidikis	Amphissis, Koroneiki, Megaritiki
Kalamon	Amphissis, Koroneiki, Megaritiki
Amphissis	Kalamon, Koroneiki, Megaritiki
Megaritiki	Chondrolia Chalkidikis, Amphissis

Salinity tolerance has been partly examined in Greek varieties. The olive is salt semi-tolerant and can tolerate the pressure of water salt up to 0.3%. It is better however to be used in water with less than 2 g of salt/L.

Other criteria that should be taken into consideration when it comes to the selection of the appropriate cultivar is the ripening period (varieties of late fruit maturity in mountainous or ice inflicted regions should be avoided), the reduced tendency of alternate bearing (eg 'Koroneiki') and last, the crop destination (oil or table olives).

3.1.4 Specific selection criteria of cultivars for table use

A basic criterion is the flesh-to-stone ratio, which has to be adequate (from 7:1 to 10:1 or higher). Also, the fruit should be of adequate mean weight (heavier than 4.5 g/fruit). The sugar content should be quite high (4-6% is supposed to be adequate). Due to the fat that 'Konservolia (Amphissis)' is low in

sugar content (2-4%), sucrose should be added during fermentation. Moreover, reduced oil content (lower than 20%) is a desirable attribute). The flesh should be of high consistency (depending on the fruit content in pectin and cellulose). The olive epidermis should be thin and the fruit should be tolerant when handled. Last, the separation of flesh from stone should be carried out quite easily. The flesh (aroma, taste) should be of excellent quality.

3.1.5 Cultivar selection strategy

The first steps for the selection of the appropriate cultivar are the market checks on the variety commercial criteria and the cultivation aim (production of oil or table olives). Next, the environmental factors in relation to the cultivar requirements, as analyzed above (soil, climate conditions, irrigation capability, water quality and micro-climate) should be studied. The cultivar behavior in the given environment and the product quality and productivity are very important elements that determine our final choice. The different behavior the cultivars exhibit towards the main olive natural enemies and diseases should be included too.

The intended plantation density, in combination with the potentiality of crop mechanization will also lead to the right choice of variety. Since a main cultivar is selected, there should be a choice of one or more pollinator cultivars so as for the most efficient pollination and highest productivity provision to be achieved.

3.1.6 The olive-oil olive cultivars.

'Koroneiki'. It appears to be the outstanding performer for oil production and is used exclusively for oil production. As an olive tree, it is very productive and tolerant to the dry climate of our country. It gives high yields and produces olive oil of exceptional quality with a fragrant aroma and pleasant taste. 'Koroneiki' grows on olive trees that can reach from 5-7 up to 15 metres in height. The leaves are dark green in colour, 5.47 ± 0.52 cm in length and 1.03±0.12 cm in width. The fruit is small-sized and it has a mastoid shape ending and one side bowed. The fruit mean weight is about 1.3 g and ends in a tit. The flesh to stone ratio is 6, 6:1 and the oil content may reach up to 27%.

The tree is of high stability in fruit yields. It displays a high yield performance, which ranges between 30 and 100 kg of fruits per tree, depending on the climatic conditions. Under unfavorable climatic

conditions, the biennial bearing effects are increased, but when irrigation takes place, the biennial bearing effects are reduced. It is considered to be an early cultivar, as its ripening period starts in early October and simultaneously it is quite demanding in winter temperatures when it comes to its efflorescence. In some cases, it is used as a pollinator for many other cultivars.

'Mastoides'. It is considered to be a low temperature tolerant cultivar and can grow in altitudes of up to 1000 metres. For high yield efficiency, it prefers rich and of average consistency soils. Its tree can reach 6-8 metres in height and it has a trunk of a large diameter and irregular in canopy shape. Its leaves have a sharp edge and are light green in colour. The blade is 6.18 ± 0.67 cm in length, 1.18 ± 0.13 cm in width, with the central leaf nerve in the upper surface being visible. The fruit displays an oval shape, its mean weight is 2.6 g and ends in a tit. The flesh to stone ratio is 6:1 up to 8:1 and the oil content ranges between 20% and 30%. It is considered to be of medium or high productivity, it has a late bloom (end of May) and its ripening period is between December and January. It is mostly used for production of fine quality olive oil.

'Lianolia Kerkiras'. An important oil-producing cultivar that yields excellent-quality oil. It is a vigorous tree with a spreading habit. Its height can reach from 12 up to 14 metres. The leaves of this cultivar are very characteristic, as they are folded over upwards (length: 6.67 ±0.59 cm, width: 1.49 ± 0.13 cm). The fruit is small in size (mean weight: 0.27 g), cylindroconical in shape, it has one side curved and a tit on its top. The flesh-stone ratio is 7.5:1 and the oil content may reach up to 19-20%.

It flourishes even on barren, stony ground soils, but it has a greater demand for moisture (being cultivated primarily in areas with a lot of rainfalls). Also, it could be characterized as a late-ripening cultivar, as its fruits are harvested late, after the first spring months. As for the productivity, while it gives normal yields, it has been observed to have biennial bearing effects.

'Koutsourelia' A cultivar of average growth (it grows on a tree that shall be 5-7 metres in height) with short stem joints on the shoots. The leaves are small-sized (length: 3.95 ±0.41 cm and width:0.88 ±0.10 cm) and dark green. The fruit has a cylidroconical shape, the mean fruit weight is 1.2 g. and ends in a small, lightly curved tip. The pit is small, elongated and its mean weight is 0.2 g and the flesh to stone ratio is 5:1. The oil content of the fruit can reach up to 24-30%.

It is a cultivar of medium productivity, which can yield relatively good quality oil. It prefers fertile or average soil and cannot grow in high altitudes. Its fruit is considered to ripen quite early (end of October).

'Adramittini'. This is a cultivar originated in Adrramition (Edremit), a city of Asia Minor. It is mainly cultivated in Lesvos and constitutes 40% of the area's olive orchards. The tree is of average growth (5-8 metres in height) and productivity, with dark green leaves (length: 5.83 ± 0.62 cm, width: 1.43 ± 0.16 cm). The fruit is roundish, slightly oval and of yellowish color. Its mean weight is 3.5 g. The flesh to stone ratio is 5.51:1 and the oil content can reach around 23%. It is tolerant to low temperatures and is mainly used for production of good quality olive oil. In general, it yields smooth oil with an excellent aroma. However, its efficiency in productivity is much more inferior to 'Valanolia', which grows under the same characteristics.

'Agouromanakolia'. It is one of the cultivars that can yield olive oil of excellent quality and this is why it is used exclusively for oil production. Its tree is of average growth and the leaves are dark green, 6.5 ± 0.5 cm in length and 1.3 ±0.21 cm in width. The fruit is oval in shape and the fruit mean weight is 3.3 g. It has no tit. The flesh to stone ratio is 6:1 and the oil content of the fruit can reach up to 30%. It is tolerant to cold temperatures and has a relatively late ripening period.

3.1.7 Table olives

'Konservolia or Amphissis'. This could be the most popular cultivar of edible olives in Greece. The tree grows to a great height with long, average-sized leaves that have a distinctive tip at the end, with a downward bend. The fruit is large-sized (the mean fruit weight ranges from 5 up to 12 g, depending on the tree volume), oval-shaped, with a dark chewy flesh, that comes away from the stone easily. The flesh /stone ratio is 10.1:1 and the oil content is about 16%. The fruit epidermis is thin and flexible. It displays resistance to wrinkles, so that it can endure the salt stress that reach 10-12%. Usually, the green fruit is more sensitive to shrinkage than the mature one.

'Konservolia' is a quite productive cultivar, which yields 15 up to 100 kg of olive fruit, depending on the canopy size, the cultivation care, etc. This cultivar is relatively tolerant to cold temperatures and very sensitive to *Verticillium*. It ripens relatively early, from mid- November to January-February, while with

the course of time and due to intense productivity, its ripening period may be prolonged up to the first spring months.

It is used for the production of Spanish-type green olives, which are picked early (from early September to end of November), as well as of black olives, which are picked from mid-November to mid-January.

'Kalamon'. One of the best table olives cultivars, which is used for the production of the popular and unique edible olives 'Kalamon'. The tree is quite robust, its leaves have an upward move and distinctive broad, deep green leaves. The fruit is of cylindroconical shape and looks like the 'Aetonichi' grape type. For this reason, it is also named as 'Aetonicholia Kalamon' or 'Aetonichia Kalamon'. On average, the fruit mean weight is 5-6 g and the pit is smooth and can be easily separated from the flesh. The flesh/pit ratio is 8-10:1, the oil content around 17-20% and the fermentation ingredients around 3-3.5%.

The tree is of average productivity, quite demanding in soil and atmosphere humidity, tolerant to soil salinity and Verticillium. Its maturity period is neither early nor late (from end November to December).

'Chondrolia Chalkidikis'. A cultivar cultivated exclusively in Chalkidiki and is known as 'Gaidourolia', due to its large-sized fruits. The specific cultivar yields cylindroconical-shaped fruits, ending in a tit. The fruit mean weight ranges from 4 to 14 g, more often though, from 6 to 10 g. On average, 120-140 fruits of this cultivar weigh one kilo in contradiction to the 180-200 fruits of the 'Konservolia' cultivar. The flesh/pit ratio is about 10:1 and the oil content comes up to 17-2-%.

The fruit epidermis color consecutively changes during the ripening period from green to green-yellow, straw-yellow, pink and ends up being a faint red black, never becoming totally black. This is the disadvantage of this cultivar and this is why it is not produced for black table olive use. Thus, it is exclusively used as a green, Spanish-type olive. Another disadvantage of this cultivar is the 'zapatera' spoilage of olives during fermentation, as well as the formation of a pink-colored ring that fleshes the pit during the fermentation process.

3.1.8 Dual purpose cultivars

'Megaritiki'. A cultivar that demands little moisture and therefore, can be cultivated in dry areas (Attiki). Also, it is quite tolerant to winter cold and flowering can be conducted with no problems. It can achieve average yields, its ripening period is from November to December and illustrates intense biennial bearing effects, unless it is well-tended.

The branches are alternately arranged and the tree can reach 5-8 metres in height. The leaves are relatively large (length: 6.64 ± 0.59 cm and width: 0.93 ±0.13 cm) ending in a pointed tip. The fruit shape is conical with a narrower base and a peak at the tip, although this may vary. The fruit mean weight is 4.2 g, the flesh/pit ratio 6.5-7.5:1 and the oil content around 21%. It is mainly used for production of good quality olive oil, as well as of various types of average quality table olives (mainly crushed olives).

'Throumbolia'. It is a cultivar quite demanding to soil humidity and cold. It grows in deep and fertile soils and it needs cultivating care, in order to bear high yields. It can yield fruits in dry-warm or chronic drought areas. According to reports, it is very demanding in cold temperatures.

It grows on a tree with horizontal branches and it can reach 5-10 metres in height. The leaves are green on the upper surface and brown-out on the bottom, 5.69± 0.51 cm in length and 1.24 ± 0.14 cm in width. The fruit is medium-sized, weighs 2.5-5 g and the flesh/pit ratio is 5-7:1. It is of dual purpose: it yields oil up to 28-30% in a natural way, as well as edible olives, known as 'throumbes'. The fruits, due to high humidity in winter and relatively high temperature in autumn, are naturally fermented, due to fungi involvement. Thus, they lose their bitterness, while still on the tree. After they have fallen spontaneously on the ground, they are picked up, washed and kept in brine.

'Kothreiki'. It is tolerant to droughts, cold temperatures and heavy winds, this is why it grows in high altitudes as well (around 800 metres). It bears moderate yields and is moderately demanding in soil and cultivation cares.

The fruit is spherical, with no tit, with firm flesh and the fruit mean weight is 4-4.7 g. The flesh/pit ratio is 3.5-7:1 and the fruit oil content ranges around 20%. The 'Kothreiki' cultivar is of dual purpose. A significant percentage of the annual production is used in table olives industry for the production of small or medium-sized black salted olives, which are of excellent quality, tasty and with a fine aroma. The part of production remaining is used for production of good quality olive oil.

'Valanolia'. This is a cultivar which grows in Lesvos in a big percentage. It has average demands regarding soil and care. In favorable conditions, it can achieve high yields. It is considered to be one of the best oil-producing cultivars, in terms both of productivity and quality. This cultivar ripens late (full ripening in February- March), although harvesting starts early (November).

The tree is semi-vigorous with an irregular canopy. The leaves are large, tough and relatively broad. The absence of a tit is what characterizes the fruit of this cultivar. The fruit has an oval or spherical shape and looks like an acorn. The fruit mean weight is 3-4.5 g, the flesh/pit ratio 2.5-5:1 and the fruit oil content around 25%. Another characteristic trait of this cultivar is the long flowering period (around 3-4 weeks), which under favorable conditions, ensures the fertilization of a big amount of flowers. It is of dual purpose and, except for the oil production, it used for table olives production, which is exported.

3.2 PROPAGATION OF OLIVES

The olive trees are propagated relatively easily, in comparison with other fruit trees. The most common propagation method used is propagation by cuttings. Propagation by root suckers and propagation by runners are used less often or rarely. This way of propagation (vegetative or asexual) yields seedlings similar to the mother tree, without any tree grafting, which start flowering in a relatively short period of time. The aforementioned is the least expensive and the only secure way for the successful propagation of the chosen trees (clones), which are distinguished for their quality and quantity characteristics. The material (graft) that will be used for propagation reasons in the ways developed above should derive from trees of a desirable cultivar, be healthy and of high productivity.

Another way of grafting that has been used in our country is propagation by grafting of wild olive tree seedlings, which are self-rooted. In other countries, propagation by seed is used. Seeds are produced by seed planting. This propagation method (sexual) is more costly and takes more time so as for the seedlings to start flowering. In this way of propagation, grafts should derive from healthy trees of the desirable cultivar, which should be checked in advance for their productivity.

It is worth mentioning that seedlings never propagate the cultivar which the seeds came from, thus it is important that they be grafted with the desirable cultivar. Moreover, there are genetic differences among the saplings, which are reflected, to an extent, to the trees (although they have been grafted), displaying dissimilarities in vegetation vigor, as well as other non-desirable characteristics.

3.2.1 Propagation by grafts

3.2.1.1 Leaf cuttings

This is the technique mainly used today, especially in modern nursery gardens provided with cooling-mist installation.

During the period of June- July, shoots with vigorous plantation and ample sun light are removed from the external parts of the tree. Then, the soft peak part is removed and grafts of 10-15 cm in length are cut from the part of the previous year, that is from the base and the middle part of the stems. On the peak of every graft, 4-5 leaves are left and the graft is cut in the lower part. Next, the graft base (1.5-2 cm) is immersed in rooting hormone dilution (4g/L IBA) for 5 secs. Then follows the graft planting on the under layer of the rooting (pearlite and peat 1:1) and maintenance in cooling-mist. For better results in rooting, intermittent cooling- mist is recommended. Grafts should be kept in a temperature of 28 °C and the graft base should be kept in a temperature 6-7 °C higher (the floor should be heated through electrical resistors).

Two-three months after the grafts have rooted, they are transplanted in bags with a soil mixture (soil, sand, soil suitable for plants 1:1:1) and stay in the nursery garden until they have reached the first stage of growth. During this period, foliar fertilization takes place and the grafts are sprayed with fungicide or pesticide, if needed. After a short period of time under shelter, young trees are ready to be planted.

Olive cultivars vary in terms of how easily they root. ‘Kothreiki’ is easier, while ‘Kalamon’ is harder to root.

3.2.1.2 Hard wood grafts

This method, found in several versions, has been used for many years, even by the growers themselves, at least for cultivars that root easily.

The grafts are parts of branches of 2-3 year-old wood, which usually have a diameter of 30 cm. They are cut during the winter season and planted either upright or horizontally. In case they are planted horizontally, the lowest part is in the soil (it will root) and the upper part is exposed to light (it will shoot). Planting is carried out initially on a graft substrate (eg moistened sawdust) until the roots are formed and next in the nursery garden. Planting could also be carried out straight into its permanent

position. The rooting success depends on how easy it is for the plant to root as well as the care it receives. For the rooting to be conducted easily, the graft has to be immersed into rooting hormone (1.0-1.5 gr / lt IBA)for 24 hours.

A variation of this method is the so-called 'grotharia' method, which is mainly used for the propagation of the 'Chondrolia Chalikidikis' cultivar. The grafts are 20- 25 cm long parts from strong branches and are planted horizontally with the upper part exposed to light. After planting, they are watered frequently and some grafts produce new trees within the first year, while most of them during the second or third year.

3.2.1.3 Ovule grafts

This is another old technique with a much higher rate of success, even in dry areas.

The grafts used here are ovules, which are characteristic swellings and appear as protuberances and are found at the level of the lower trunk part and roots, close to the collar of large trees. Ovules are able to produce new trees as they contain both root primordial and dormant buds.

Ovules (their weight varies from 100 g to 3-4 kg) are cut from the tree and placed in sand or light soil at the end of winter, where they remain for 2-3 years in order to root. After grafting and rooting, large-sized ovules are cut into smaller ones, which in turn give 2-3 young trees each.

Despite the high rate of success, along with the other advantages of this technique, it lacks in the fact that during the removal of the ovules, the mother tree is injured. Moreover, because of the fact that old trees, which ovules are removed from, may come from grafted wild olive trees, young trees derived from the ovules must always be grafted with the same cultivar.

A variation of this technique is the production of grafts by using a part of the trunk which lies on the colar of the tree up to 50 cm depth into the earth. From this part, a zone carrying the bark and part of the wood is cut with a saw. Then, this zone is cut into pieces of 200 gr each. These pieces, known as 'heels' in Crete, are used as grafts and should carry both piece of wood and the equivalent piece of bark. In this case, too, there are both advantages and disadvantages, as in the case of ovules.

3.2.2 Propagation by suckers (or pollards)

This propagation technique is used by growers quite often, even by the growers themselves, with high rate of success for the cultivars which produce many suckers. It is rarely used by nursery gardeners, as not many mother trees with suckers can be found. Suckers are shoots developed on the base of the tree trunk. Usually, they produce roots too, while they often form a small swelling (small ovule).

To make it easier for suckers to produce their own roots, the base of the tree is covered with a thin layer of soil. Shoot girdling can further enhance adventitious root formation.

Suckers are cut from the main trees from February to March with a pick or other tools, ensuring that suckers are removed from the stock plant along with the roots or part of the root. They are planted directly into their permanent position or better, they grow in a nursery for a year before they are planted out. The shoot is cut into 50 cm before it is planted.

Suckers should be taken by self-rooted trees (not grafted with wild), otherwise they should be grafted with the desirable cultivar.

Grafts, which develop roots easily, can be grafted too.

The disadvantage of this and the previous technique is that the stock plant is injured, which makes it sensitive to diseases, such as Verticillius.

3.2.3 Propagation by wild olive tree grafting

This technique has been used in many areas of the country for the installation of olive groves in bushy areas, where there were a lot of wild olive trees. In our days, it is used less frequently, by individual growers.

Wild olive trees are grafted on the spot, after the side shoots have been removed and after they have been pruned strictly.

They can also be uprooted and transplanted in a nursery, where they are grafted, after they have grown enough. The grafted wild olive trees are planted in their permanent position in the beginning of spring, 2-3 years after having been grafted. They start fruiting 5-6 years after they have been planted. The disadvantage of this technique is that the olive grove, which will be created by grafted wild olive trees, will be dissimilar among the trees in terms of vegetation vigorousness.

3.2.4 Propagation by rootstock seedlings and grafting

This is a widely used method, but not as much as leaf cuttings in cooling- mist. It is conducted in two stages, which are: the creation of scion from selected pits (seeds) and the grafting of rootstocks with the selected cultivars.

Concerning the first stage which includes the propagation by seeds and which will be used as rootstocks, it has to be highlighted that the olive pits have difficulties in developing roots. This is due to the fact that the water's entrance to the hard endocarp (the hard seed shell) is hindered, the possible existence of germination inhibitors within the endosperm (tissue between the germ and endocarp), as well as the germ's dormant state.

In practice, nursery gardeners use wild olivary nuclei (they have the highest vegetation rates) or small-sized fruit cultivars nuclei (eg 'Koroneiki', 'Koutsourelia' etc), which have high vegetation rates and produce seedlings of a satisfying skin width, of average length stem (joints) and a sufficient amount of thick roots. After the fruits have been harvested from selected trees (stock plant), then follows the process of pitting, which is carried out either mechanically or by hand. Next, through various techniques, such as the removal of the peak part of nucleus with pliers, trying not to injure the germ, the immersion of the nuclei in dense sulphuric acid or diluted caustic solution (the needed time of immersion and concentration of solution depend on the cultivar), the nuclei are processed so as for the entrance of water into the seed to be easier. Next, nuclei are layered into wet river sand up until spring; therefore they are germinated in the nursery. Seed plants stay in the nursery for about a year until they get to have a satisfactory size, so they can be transplanted in the nursery.

The next stage is seed plant selection-sorting, which is based on the criterion of their growth (stem height and diameter). The plants which are selected in this stage are transplanted in plastic bags or pots of polyethylene dilution and stay in the nursery to grow for one up to two years, until they are ready to be sold.

The disadvantages of this technique are the difficulty of uniformity and high rate nuclei sprouting, the irregularity of young trees, in terms of vegetation vigorousness, due to the different genetic makeup of seed plants, as well as the fact that it is quite time-consuming. The time needed from the stage of fruit harvest to when the time for the young trees to be sold has arrived ranges from 3 to 4 years.

3.2.5 Olive tree grafting

Olive tree grafting takes place either in the nursery on young seed plants or outside, so as to succeed taming of young wild trees or replacement of the cultivar to old large olive trees. The appropriate season is spring, (March up to beginning of April), after the frost risk is over and after the skin starts to come off.

3.2.5.1 Young trees grafting

Young trees are suitable to be grafted when their trunk has reached 1 cm in diameter. Before grafting, all buds are removed sideways. The grafts are taken from well- formed buds of the previous year (up to 0.5 cm in diameter) from selected trees of the desirable cultivar.

The most common way is the shield-shaped or T-inosculation, during which a part of trunk is used as graftwood (in the shape of a shield) with one flowering bud enough grown. The success rates are higher if the flowering bud has already been inserted in a very young bud when used. In both cases, the rootstock is cut in a T -shape, where the patch is tucked.

For a bigger success, large trees are grafted by tree patch in chip inoculation. In this case, too, the graftwood is part of the trunk (but in a rectangular shape) with one scion. The rootstock is cut on the bark with two horizontal and one vertical cut, where the patch is tucked.

For this type of inosculations to be successful, the patch should be preferably tucked on the north side of the rootstock, so that it faces away from the sun.

The competing buds that grow below the new buds should be removed as soon as possible. The ties are cut 2-3 weeks after the patch budding. If the patch budding is successful, the rootstock is cut 10 cm above the patch during next spring. If it does not succeed, re-grafting can be applied during the same year, after irrigation of the rootstock.

3.2.5.2 Cleft graft of larger trees

This type of grafting is carried out if we want to change the cultivar of a larger tree. Three or four hours before grafting, tree limbs are cut in an adequate height, so as they will not sprout a lot of buds from

dormant scions. It is wise not to cut all limbs; instead, one or two should remain , so as to fuel the tree and be grafted or removed the next year.

Patch budding is usually carried out by subshell ingraftment. Pieces of the scion (budwoods) 6-12 cm in diameter, with four scions (two ovules) from 1-2 year-old buds from selected trees of the desired cultivar are used as grafts. Budwoods are prepared in advance; they are cut, their leaves are removed, and they are stored in a wet and cool place in plastic bags. During grafting, the budwood base is transformed into a one-sided cone with a side clean cut on one side and is tucked on the rootstock, under the bark, where a vertical cut has been made. 1-3 budwoods are placed on each branch, depending on the limb diameter, and they are tied. Grafted trees do not receive nitrogen for 2-3 years, but they are frequently irrigated. Limbs start fruiting again during the third year after they have been grafted.

For a quick change of cultivar on young trees, which have thin limbs (around 1.5-3 cm) the technique of side inserting can be used (Figure 4). The limb is cut in an adequate height and a vertical cut is made on it, engaging part of the bark and wood. As woodstocks, pieces of one-year-old buds (0.5 in diameter) along with their leaves are used here. Their base is transformed into a one-side cone; then, they are placed on the rootstock cut and are tied.

Cleft grafting can have better results, if it is carried out by an experienced grafter. The excellent contact between the rootstock and the scion is of great importance, too. In this case, the cuts should be totally clear (they should be implemented with a sharp grafting tool, in one single move) and the graft should be tucked in a way that cambia (right below the bark) of the two sides touch each other as much as possible). The naked wounds of the rootstock and the scion should be covered with wound dressing or melted paraffin wax, so as to avoid dehydration and decay.

3.3 OLIVE GROVE DESIGN AND INSTALLATION

The olive grove installation requires a detailed design long before the tree planting starts. The grower, after having carefully studied the production factors and the agri- economical aspects of the area, he/she will have to make some technical decisions, concerning the farming system he/she will follow in order to carry out various agricultural activities (irrigation, fertilization, pruning, plant health, harvesting), the planting system he/she will implement and the cultivar he is going to plant. During the study of all the aforementioned, special attention should be given to those factors, which are crucial for the results of the olive tree plantation, and more specifically, to the steady factors, such as the climate,

soil consistence, cultivars, etc, which cannot be repaired, once decided. However, the grower should be able to alter the variable factors, such as pruning and cultivation care (fertilization, irrigation, etc) so as to enhance the olive grove productivity. Besides the proper designing of the olive grove, the olive oil production is also affected by factors related to the soil preparation, planting, as well as the care of the young trees during the first years of their growth.

3.3.1 Olive grove site selection

In order to decide where to plant an olive grove, the local climate effects, the soil appropriateness and the socio-economic capacities offered in an area should also be taken into consideration.

3.3.1.1 Soil and weather requirements

The olive tree grows and fruits in a satisfactory level in a warm temperate and subtropical zone, which is characterized as the olive tree zone. This zone lies between the 30° and 40° north and south latitude and is characterized by the Mediterranean climate with mild and wet winters and hot and dry summers. Beyond the borders of this zone, the olive tree does not fruit in satisfactory levels, as in more than 45° north or south latitudes, it suffers from low temperatures. Below 30° latitude, close to the equator, the olive tree grows, but does not yield fruits.

The olive tree commercial cultivation is restricted where the climate and soil are combined in an excellent way. What is more important out of the climate factors of the crop are: temperature, rainfall, humidity, snowfall, hail and winds.

As for the temperature, the olive tree is a demanding tree. During sprouting period in spring and summer, it needs high temperatures to develop new vegetation and fruit. High temperatures are also important for the normal growth or fruit ripening. Ground frosts during spring or winter are detrimental for the crop; temperatures as low as -10 °C may damage the tree, ie cause branch drying or even tree drying. Commercial olive trees should not be planted in sites, where temperature falls below -5 °C. In autumn, temperatures between -2 °C and -4 °C may damage the fruit, because the fruit shrinks (especially the green olive) and their quality is degraded. Higher temperatures, when combined with dry winds may damage the crop, because they cause dryings in the vegetation and fruit shrinking, due to the high percentage of humidity losses.

In winter, olive trees need low temperatures from 7 °C up to 16 °C, so as to differentiate flower buds. This is due to the fact that the olive tree only grows in tropic weather conditions, but it does not yield fruits.

Rainfalls are an important factor for the olive tree fruiting effectiveness, especially where there is no irrigation. In the dry areas of the country, where rainfalls are limited (around 200-300 mm of rain per year), the olive tree fruits only where the soil retains moisture. In areas where the rain rates are 400-600 mm, it fruits satisfactorily. In areas, where rainfall rates are more than 600 mm, fruiting is satisfactory, since soil drains and no further problems concerning soil humidity reserves are caused.

High relative humidity in the olive tree environment is not good for the crop, as it creates excellent conditions for many diseases (leaf spot etc). Low relative temperature is positive for the tree growth, but it enhances the tree needs in water.

Snowfalls cause branch damages, as they break, due to the snow weight, which is retained on the tree, especially when it has not gone through pruning.

Hail is always detrimental, because it destroys small branches with leaves and fruits and, in this way, it indirectly make trees susceptible to cancer (Pseudomonas syringae pv savastanoi).

Strong winds cause damages to the crop, as they create humidity losses and, thus, tree growth is restricted.

As for the soil, the olive tree does not seem to be a very demanding species. The tree grows satisfactorily in various soils. Nowadays, most olive groves have grown in such poor soils, where other fruit bearing trees rarely survive. The olive tree, however, grows and yields fruits in sandy loam soils which have good levels of humidity and drain well. Very fertile soils may exhibit very rich vegetation, which is negative for tree fruiting. Olive trees grow and yield fruits in satisfactory levels in moderate acidic or alkaline soils. Olive trees are able to withstand a soil pH of 8.5, where other fruit bearing trees do not grow. High subsoil water level restricts tree growth to a great extent and not well drained soils should be avoided for olive tree plantation.

3.3.1.2 Socioeconomic capacities

The olive tree cultivation is located basically in semi mountainous areas, so it is not possible for the agricultural activities to be carried out mechanically. This results to the fact that olive oil cultivation

depends to a large extent on labour allocation, something which should be taken into serious account, when it comes to new olive groves designing, as they are labour- demanding during fruit harvesting.

Concerning the edible olives, it is important whether the area is close to factories dealing with fruit canning, so that they are carried securely. Many producers allocate their product to factories that belong to organizations or other bodies.

3.3.2 Selection of farming system

The olive cultivation faces many problems, when traditional ways of farming take place (low efficiency, production costs increase), which gradually lead to the olive production abandonment in the areas with adverse conditions. This crisis could be solved, on the part of the producer, by modernizing the way olives are produced and allocated, according to the new trends in tree growing products production. All this should be based on: a) the early tree allocation for production, b) implementation of adequate cultivation methods and, c) cultivation activities mechanization, which allows the yield increase and the production costs decrease.

Traditional olive tree farming systems cannot comply with the aforementioned targets. Lately, quite a few efforts have been made, in order to try intensive types of olive tree farming based on (a) planting density in combination with low bush-shaped trees and (b) uncultivated soil combined with drip irrigation and pesticides use as well as (c) the mechanical harvesting.

Dense planting systems combine small-sized tree formation with high planting density. Efforts made with the use of appropriate cultivars, such as 'Koroneiki' etc and with the proper propagation material (hardwood grafts, leaf cuttings), which allow the olive tree to grow in a low bush-shaped tree, have brought positive results concerning the dense planting method. With the use of bush-shaped olive trees, apart from the efficiency in stremmas, the degradation of fruit surface in low-budget levels for picking from the soil are succeeded. Thus, trees start fruiting earlier (in the third, fourth year after they have been planted). The intensification of olive industry that has been managed through the bush-shaped tree plantation caused problems, due to the tree canopy congestion in these cases, where the planting distance among trees decreased excessively. This is why there should be a provision during tree planting for the right design of planting that allows thinning in modernized dense planted olive groves.

In steep hillsides, where soil erosion is facilitated by planting, the technique of uncultivated soil has great success rates. According to this technique, weeds are left unattended for a short period of time so

as to grow, and then they are killed with pesticides. The results are even better, when the use of pesticides is followed by drip irrigation. In this way, weeds are controlled, water is saved and the cultivation that affects soil fertility negatively is avoided. The high cost of pesticides, though, restrict and hinder the use of this technique to all olive growing areas.

The use of farming systems, which aim at the mechanical harvesting, should be taken into consideration while the olive grove is designed. Such kinds of systems, which can be applied to certain types of cultivars only and in lands of smooth topography, aim at the tree growth in the appropriate design and in distance among them, so as for the vibrator use to be easier. Olive trees with many branches, low bush-shaped trees and densely planted trees are appropriate for mechanical harvesting, which is made easier, if they are pruned in the right way and with the use of various fruit growing substances that bring uniformity in fruit ripeness. Mechanical harvesting may be applied to certain types of cultivars, especially to 'ladolies' and less to edible olives that are harvested when they are green in colour.

3.3.3 Olive grove plant design

For an olive grove plant design to be elaborated, all the aforementioned factors, as well as the agricultural performance that is going to be used by the producer as for the investments in funds, the craftsmanship that the farming process needs, the level of farming works mechanization we aim for and the changes we may have in terms of tree fruiting after many years (35-40 years) are all taken into consideration. The planting system makes reference to the plant density and the way trees are arrayed in the specific piece of land, so as for an olive grove to be installed.

3.3.3.1 Planting density

Planting density refers to the number of trees attributable to the surface in question and is determined by the distance and the way trees are arrayed. Planting density is related to the tree canopy formation shape and is standardized at: fruit surface/ surface olive trees can reach in periods of high yields. For the determination of planting density, the lubricant substances the olive tree needs, sunlight and soil humidity, as well as financial results aimed at the production must be taken into consideration. The poorer and shallower the soil is, the less dense the planting is. Rainfall is also a determining factor for the planting density. The less it rains (with no irrigation applied), the less dense the planting should be, so as for each tree to cover a larger land space. In areas with a lot of rainfall, density can reach 20 up to

30 trees per stremma. High planting density may also cause canopy congestion and this may lead to decrease in sunlight intensity and the movement of the fruiting zone only to the higher levels of the trees, where sunlight is ample. This results to the gradual increase of the tree height and the formation of very long trunks. Olive trees that grow on the islands of the Ionian Sea, and more especially Corfu and Parga are examples of such cases. Venetians facilitated-enforced dense planting in these areas during their dominance. This phenomenon changed the initial formation of vigorous cultivars, such as 'Lianolia Kerkiras'. As a result, they ended up having very long trunks over 25 metres in height. These olive trees became forest type trees.

Moreover, canopy density creates favourable conditions for olive natural enemies and diseases. In many olive groves, where dense planting was implemented, canopy density created a lot of problems with the passing of time and, along with the exhaustion of the soil reserve of nutrients, resulted to the efficiency decrease in unprofitable for the producers levels.

In order to avoid disadvantages of dense planting, certain trees are uprooted during the stage of tree fruiting, so that the remaining trees should be in an appropriate distance among them. In practice, this is not implemented as much by the growers, as they hesitate to remove trees that grow healthily and this makes the situation worse year by year. In certain areas of the country, trees are pruned strictly in such types of olive groves, so as for the trees to get as much sunlight as possible; however, this method does not always yield positive results.

Some intermediate planting systems are provided for dense planting; they involve gradual tree thinning (once or twice), so that the olive tree should be in optimal density without the existence of any problem, as far as the high tree competition and the excessive shade of their canopy are concerned.

3.3.3.2 Distances and planting systems

The planting distance mainly depends on soil fertility, the rootstock in use and vegetation vigorousness of the cultivar that is going to be planted. Dense tree planting increases, on the one hand, the production per stremma during the first years of the olive grove installation, but on the other hand, it contributes to the significant production decrease, due to the tree congestion. Trees not densely planted result to the bearing of low yields during the first years of the olive grove installation, which become higher when trees get older (10-15 years old). If all the factors mentioned above are taken into consideration, then the appropriate distance must be measured as below:

$$\text{Tree height} = \frac{\text{planting distances}}{2} + 1$$

Tree height is supposed to be known and is estimated approximately, according to the vigorousness of the rootstock in use and the cultivar (Pontikis, 1981).

In lowlands and slopes, most olive trees are planted in the form of a square, diamond or in lines (rectangles), while in the semi-mountainous and mountainous areas, planting is more irregular.

The planting system in hill terraces is quite popular to many areas in Greece. The formation of hill terraces in conventional olive producing areas was implemented during the Venetian period after the building of dry stone walls preventing landslides and filling of the blank space with extra soil. These hill terraces 'benches' with olive trees are still kept in excellent condition in many islands. In many areas (Crete- Lesvos), the olive tree planting with the dry stone construction of individual hill terraces was usual. This type of planting system helps trees grow, especially during the first years of their growth.

In areas of moderate gradient (3-25 %), planting should be implemented at soil contours (contour farming), that is following the curvature of the land. In practice, this system is hardly implemented, as there is lack of the necessary machinery (caterpillar tractor). For this reason, olive tree growers use the usual planting systems (in the form of squares or rectangles) and the cultivation is carried out with common tractors along the surface gradient, so as not to run the risk of the tractor rollover, as the soil of the olive grove is eroded, if farmed over-intensively.

3.3.3.3 Olive cultivation systems and their characteristics

The big and serious problems of conventional farming of the olive trees (conventional olive groves), as well as the great scientific and technological developments resulted to the intensification of farming. The main reasons of intensification were the increased needs in olive- produced products, the technological, economic and social development, which led to the farming mechanization, and the decrease of labour in farming. Low productivity and the high production costs of conventional olive groves (pruning and main harvest) were also causes to seek new and more productive farming types.

Initially, conventional olive groves were rendered to intensive conventional olive groves through the use of mineral fertilizers, irrigation and more intensive farming. Next, with the increase of planting density and the use of modernized formation shapes (palmetto, bushy, pyramid shape or conical shape), olive

groves became modern intensive olive groves or densely planted olive groves, which increased their production efficiency per stremma even more.

In this way, three main olive tree cultivation systems took shape in the European countries and our country, too. In the last years, though, mostly in other countries, a fourth cultivation system with super-intense plantation and very intensive, fully mechanized olive groves is developed. This system was recently introduced in Greece, too.

1. Conventional olive groves. Planting density is 5-12 trees/stremma and they are characterized by lack of systematic cultivation and the production efficiency is very low (20-150 kg of fruits/stremma).
2. Intensive conventional olive groves. Planting density is 8-25 trees/stremma and they are characterized by the use of mineral chemical fertilizers and the partial irrigation, while the production efficiency ranges between 150 and 400 kg of fruits/stremma).
3. Modern intensive olive groves or densely planted olive groves. Planting density is 20-50 trees/ stremma with planting distances 3x6, 4x5, 5x7, 6x6, 6x7, 6x8 metres. These systems are characterized by the modern tree formation systems (palmetto, bush, low bush, pyramid or conical) and the potential use of vibrators for easy fruit harvesting. Also, the use of chemical fertilizers and herbicides is very intensive and the production results very high (400-1200 kg of fruits/stremma).
4. Super high density planting system or super high intensive olive groves system was added in the last 15-17 years and has the following main characteristics: the planting distances are 1-1.5x 3-5 metres, where planting can reach 140-250 trees/stremma and yield efficiency reaches 800-1300 kg/stremma. The canopy takes the conical form or fusiform (cypress-like) or palmetto. These systems are characterized by the mechanized harvesting potential, as well as the mechanical pruning of the olive trees.

3.3.3.3.1 Super-intensive planting systems (20-50 trees/ stremma)

Super intensive planting systems started 35-40 years ago and are still implemented with great success rates in many European countries. In general, the installation of this system must be carried out after careful consideration and study of many factors, such as soil, climate, cultivar, the potential to use modern agricultural machinery etc.

The prerequisites of this system's installation are:

1. Increased soil fertility for the increased fertilizing needs
2. Existence of necessary water reserves if rainfall is not enough
3. Potential of special harvesting and pruning machinery use
4. The soil slope should not be high for the machinery to have access and be easy to use
5. Cultivars. In general, most Greek cultivars correspond to super intensive planting systems. However, the ones which adapt better are the non-vigorous cultivars, such as 'Koroneiki'.

The most important pros of intensive planting are:

- The early entrance of trees in the fruiting period (in the third or fourth year after that have been planted)
- High productivity that reaches up to 1000 kg of fruits/stremma.
- Production cost decrease, which can be attained with the use of machinery and the increase in efficiency in stremmas.
- Quick soil tree leaves covering, as well as optimal soil exploitation that holds up thinning out, are ensured.
- Foliage is closer to the roots and in this way, fertilizing elements and water are utilized better.
- Farming activities are carried out better, due to the lower height of trees and the use of machinery.

After installation problems. Years later, problems, due to lack in tree growth control, may arise. The size of problem varies from to cultivar to cultivar. The problems raised are as follows:

- Tree congestion and mutual shading
- Productivity decrease due to root mutual shading and competition

In these cases, the suggestions are:

- Uprooting of 25-50% of trees depending the initial planting density, or
- Regeneration pruning in 25-50% of the trees.

More radical are the solutions of finding dwarf rootstocks and the selection of non-vigorous cultivars.

3.3.3.3.2 Super intensive planting systems (140-250 trees/stremma)

The aim of the introduction of this kind of systems was the full mechanization of fruit harvesting and the simultaneous production cost decrease. Those systems have been tried out with success in certain deciduous trees (apple tree, pear tree, peach tree). The basic prerequisites for this system to succeed are the combination of dwarf rootstock and dwarf cultivar or self-rooted dwarf cultivar in combination with the appropriate canopy formations, such as palmetto, spindlebush or espalier. The dwarf rootstock has a restricted growth of root system, which decreases competition on receiving nutrients between plants, while the cultivar's low vigorousness restricts the canopy volume and problems concerning the tree mutual shading are avoided. The lack of dwarf rootstocks and low vigorousness cultivars are the basic reasons why these systems should not be implemented on other deciduous trees.

In the case of the olive tree, despite the long research efforts, no dwarf rootstocks have been found. From the Greek cultivars, 'Amigdalolia' is probably the only dwarf cultivar in the world, but it is not worth being propagated. Unfortunately, its use as a rootstock was banned, because it does not spread the quality of dwarfism to the grafted cultivar. What has been achieved (in Spain and Italy) so far is the selection of some semi-dwarf cultivars (cultivars of low vigorousness), that have the potential to grow in a conical shape (cypress-like shape) and allow in this way the very dense planting. One of these types of cultivars is 'Koroneiki'. So far, high intensive planting systems have been tried out only to oil-producing olives. However, the problems of the root system competition and mutual shading are more intense and cannot be dealt with permanently, but only temporarily. Thus, those problems arise during the 6^{th} year after planting and in the 10^{th} year, they become even more intense and there is need of partial or total canopy regeneration. Certain researchers suggest uprooting and replanting of the olive groves over again.

The super intense planting systems have started being implemented in Spain around 18 years ago (since 1990). It is implemented, apart from Spain, in the US (California), Chile, Argentina, Australia, while it is also tried in Tunisia, Morocco, Italy, France, Portugal, Israel and other oil-producing countries. During the last 2-3 years, they have started to spread in our country, too. Only around 400,000 stremmas are cultivated nowadays in the whole world, the 65% being in Spain. With the use of this system, trees are planted very close to each other (eg 3x3, 1.5x4, 1.25x4 metres and so on). The number of trees per stremma is proportional to the above measurements (eg 111, 165, 200 and so on). The tree shape is usually cone-shaped (cypress), Y or palmette and trees are steadied on permanent supporting system (stakes and wires). It is an production industrialization system and presupposes the harvesting and

pruning mechanization, as well as the existence of large bed surfaces, so as the use of high cost machinery to be cost-effective.

The most important pros of super intensive planting system, in relation to conventional thin planted cultivations, and intensive planting, are the following:

- Trees enter the fruiting season earlier (usually in third or fourth year), while they reach full production during the sixth year after the olive grove installation.
- The yields/stremma in the first 8-9 years is much higher than those in thin planting and even higher than in dense planting.
- Through crop mechanization (in pruning and main harvest), cultivation costs are reduced in a great extent.

The cons of the super intensive planting system are:

- Increased cost of initial installation (more trees/stremma) and supporting system with wires, which is necessary (30 trees/ stremma).
- The total cultivation costs for 15 years after the installation (irrigation, fertilization, pruning, plant protection) is estimated three times higher in price in relation to dense planting.
- Increased water flows, pesticides and fertilizing needs. Water demands, the lack of which should make us worry, especially being aware that the olive tree can grow with no irrigation.
- Pruning and harvesting machinery purchase costs
- Problems due to tree competition and shading after the 6^{th} or 7^{th} year of installation with direct production decrease. In this case, special pruning is needed, in order to avoid shading and to keep height under 2.5 metres, so that the mechanical harvesting, which is an important advantage of the system, can be implemented. Later, after the 10^{th} or 12^{th} year, regeneration pruning or tree thinning or uprooting is needed.
- Tree shading may cause more intense disease and mycological problems due to tree mutual shading. Tree productive life lasts for around 10-15 years.

The quality of the oil produced, even if not studied enough, can be affected negatively by the intense mutual shading of trees. From experiments having been carried out, it is already known that oil content in these systems is lower by 20% comparing to that in dense planting. The most important of all is that annual net income that producers receive in a span of 15 years, is estimated to be half in relation to that of dense planting. Beyond this, though, for the installation of such olive groves, the following are required:

a) Very fertile, not heavy irrigation soils and lowland areas (not sloping so as for the machinery to be able to move, b) Special cultivars with reduced vigorousness that can adapt to dense planting. Up to this day, it has been found that 3 cultivars, Greek 'Koroneiki IRTA i-18' and Spanish 'Arbequina' (clone i-18) and 'Arbosana' (clone i-13), as well as some others, such as 'Askal' in Israel, can adapt well.

Up- to-now scientific data concerning thriftiness and durability of the system is contradictory or rather negative.

3.3.4 Soil preparation

Before planting, soil is prepared, so that various cultivation cares be implemented in an easier way and the trees grow better. If the area is cultivated for the first time and is covered with bushes, soil is cleaned up and is cultivated for some years with large crops plants, usually graminaceous. Thus, through frequent soil treatment, root residues are removed, which, if derived from forest types, they are possible to spread corky root rots (*Armillaria mellea, Rosselinia necatrix etc)* to olive trees. Wherever there are deep-rooted weeds that cannot be rogued (cynodon dactylon, wild oat, nutsedge and so on), deep tillages are carried out, so roots can come out to the surface and be destroyed. Such weeds are removed with great difficulty after the installation of the olive grove and may delay the young trees growth.

When soil is inclined, it is appropriately farmed, so that planting can take place in contours; terraces are built in order to facilitate soil activities without the danger of soil erosion. For slightly inclined (3% up to 25%) hilled areas, contours are lined every 8 up to 15 metres and cultivation is carried out with special tractors (caterpillars). In areas of side and steep gradients (25-30 %), terraces are built in advance. Such terraces are successfully built, if combined with wall preventing landslide building; in this way, the soil is better protected against erosions. The implementation of both cases presupposes soil and site survey in the area and depth, where earth activities will be carried out.

After leveling, a deep tillage takes place so as to facilitate the root system growth in depth. In deep tillage, basic fertilizers, mainly phosphate and potassic fertilizers are added, so that nutrients reserves will be created in the zone, where the olive tree roots will grow. Such fertilizers are difficult to reach the root zone with normal surface fertilizations, as they are restricted on the upper levels of the soil. Usually, fertilization with phosphate and potassic fertilizers is not necessary, if the field has been used

before in large crops for many years. It is proper, though, before the main fertilization, for a soil study with samplings from 4-5 points of the field and various soil depths (30, 60, 90 cm) to be carried out.

If there are plans for irrigation implementation, it is wise to have the irrigation system installed before young trees have been planted. For the implementation of surface irrigation, leveling is important, so that water in the olive grove moves and be distributed in an easier way. For drip irrigation, water distribution should be installed during the olive grove installation, so that farming activities should not become complicating.

3.3.5 Young trees planting

After determining the position of trees, the holes are dug. If the field has been tilled in depth, holes are dug easily with a shovel in a size that can be endured by the root system of young trees. In case the field has not been ploughed, holes are dug with a mattock of larger dimensions (diameter: 1.5 cm, depth: 60 cm).

Young trees growth is achieved easily in the first stages, if during planting, well-digested manure is added. However, manure should not come in contact with the root system. For this reason, it should be mixed with soil when holes are dug and placed at the bottom of the hole. Over the mixture, a bed of soil is placed before the tree is planted. The incorporation of basic fertilizers, phosphate or potassic, in the holes is not recommended, as they may harm the roots. If the soil is poor, it is more preferable for chemical fertilizers to be incorporated throughout the field before the last ploughing during the soil preparation.

Young trees are carried and planted in plastic or cloth bags with a ball of soil in them or in pots. Large trees are planted bare-rooted. The canopy of the latter has been restricted enormously, so that any moisture losses should be avoided. Their carriage, though, should be done with no delay and all precautions (root system covering with wet cloth) should be taken, in order to avoid any moisture losses.

Young-aged trees are preferred for planting, as they have not lost a great part of their root system during replanting. Those young trees have fewer losses during planting and if they receive the appropriate cares, they grow in a quick pace and reach the size of big trees. In more favourable areas with enough rainfalls or enough irrigation water available, adequately grown trees of an older age with fewer losses during planting may be used.

The most appropriate planting season for the southern part of Greece is from November to December. In northern areas with a lot of rainfalls, it is recommended for planting to be carried out with a delay (from February to March), after frost risk is over and before the new vegetation starts. Extended rainfalls and low winter temperatures are possible to cause losses to young trees.

During planting, young trees are placed in the pit, in the same depth they were in the nursery; planting is carried out in 5-10 cm deeper in dry areas only. Pit filling is carried out carefully, preferably with surface soil first, in order to cover 1/2 up to 2/3 of it, then soil is pressed around the collar area, so that the soil comes in contact with the roots. After soil pressing, irrigation follows and as soon as water is absorbed, the pit is filled up with soil up to the top. Newly planted young trees should not be left unuttered and for their protection against drought, the surface around the collar area is covered with straw, so as for soil drought to be avoided.

3.3.6 After planting cares

During the first years after planting, all cultivation cares are carried out, so as for young trees to grow and enter the fruiting season early. Frequent irrigations take place and soil is kept clear of weeds. If it is a case of crop combination, we should manage combined plants not to compete against tree growth. Also, the cultivated area should become smaller in size gradually, so that the combined crop will not be to the detriment of the olive tree crop. It is important not to combine crops, such as tomatoes, potatoes, cotton etc, as they may facilitate the spread of hydromycosis (*Verticilium albo – atrum).*

3.4 OLIVE GROVE SOIL FARMING ACTIVITIES

3.4.1 Soil cultivation

Water is the main restrictive factor for dry olive groves, which make up the majority of olive groves in our country. Tree yield efficiency depends in a great deal upon the water quantity retained in the soil during winter rainfall season, as well as on whether this amount of water will be available to the trees later in crucial points of new vegetation, flowering and fruit growth. Thus, it is of great importance to succeed maximum water retention and reduce its losses during spring- summer to the minimum through farming activities and other measures taken against weeds.

Weeds are the most important cause of water losses of the olive grove soil. As they grow, a lot of water and nutrients are kept away. The olive grove is of course known for its ability to find and utilize any trace of water left in the soil. However, weeds, which are adapted to the dry environment of the olive grove, have the same ability, too.

The final damage that weeds make to the olive groves varies a lot, even within the same olive grove, and depends on their density and the weed species (some are more competitive). However, it depends on their season. Thus, in winter, weeds do not cause water losses; on the contrary, they increase water retention, especially in sloping areas which they protect against erosion, as well. For this reason, weeds in winter are not considered detrimental and the only reason that can render them undesirable for a period of time is because they hamper the olive fruit harvest (they are tangled in the nets, they make collecting olives by hand or through machinery difficult, etc). From spring onwards, weeds start becoming very harmful, as they remove the saved water that trees will soon need. Thus, at least one month before the onset of the new vegetation season, weed removal is recommended.

3.4.2 Farming (or pest control) systems

Because of the fact that both conventional soil cultivation (mechanic) and pest control in more modern ways (chemical) have the same target and what they target for is water savings, which is mainly achieved with weed removal, when it comes to olive grove cultivation system, in essence we mean pest control system. In this sense, the systems which are followed in most countries nowadays are: soil farming and non-farming (chemical farming).

In the first system, which is in essence the traditional way of pest control, regular olive grove soil ploughing or milling are carried out, so that the field is weed-free all year round. Along with soil farming, fertilizers incorporation takes place at the same time and, as it is believed, better water retention, better soil ventilation etc are ensured, which however are always under question.

In the second system of farming or non-farming (chemical farming), no ploughing takes place. Weeds in this system are controlled through the appropriate pest control implementation, usually by the end of winter. Pest control is completed in spring and winter through post emergent herbicide local implementation for pest control that may germinate and grow later on.

In countries such as Italy and Spain, the second system became popular and is implemented in a significant number of olive groves. The same did not happen in our country, where the first system

keeps being implemented in a great number of olive groves, while in many areas, no system is really implemented.

Both systems have pros and cons. Despite the fact that a lot of discussions have been carried out in favour of the former or the latter, the truth lies somewhere in between. That is to say that special conditions of each olive grove are those which determine which system the farmers should opt for, always bearing in mind the pros and cons of each one of them. Then, it is of great importance for the installation of any system to be accurate, as a wrong installation may bring adverse effects. As an instance, ploughing during an inappropriate period may cancel all the benefits in water reserve that existed up to then. Also, wrong herbicide implementation may cause toxicity problems in trees.

A lot of experiments on benchmarking of the two systems have been carried out so far. The general conclusion is that concerning water saving, the two systems are equivalent. As for yields, the non-farming system seems to dominate giving higher yields (in out of 92 experiments carried out in Spain, 81 gave higher yield in non-farming up to 40 %.) This increase is accounted for the fact that in non- farming, there is better root growth (even on the soil surface); this simultaneously means higher levels of tree vegetation and fruiting period. In non- farming, trees yield more fruits, which, in years of high yields, are of a smaller size. This should be taken into consideration, when olive groves are intended for table olives, where there is a risk in quality decrease and non- farming should rather not be implemented.

3.4.2.1 Pros and cons of the systems

In order for the right choice of system for a specific olive grove to be made, the criteria below, with different gravity each, according to the special conditions of each olive grove, must be taken into account.

Cost of the system. The investment in question should be compared in agricultural machinery (it varies based on the olive grove type and size) and the operating costs (man- hours, fuels etc) with the equivalent costs for the purchase of spraying equipment and the herbicides implementation. Usually, costs are in favor of the latter system, but the contrary may as well happen in many special occasions, too.

Soil impact. Possible impacts of farming and non- farming in soil structure must be checked. Moreover, the way filtration in depth and water retention, as well as surface water runoff and soil

erosion, will be influenced by the two systems, should be checked, too. Different soils are influenced in a different way.

For example, when certain soils are farmed and ploughed through machinery very often, a compressed layer is created in shallow depth, which is impermeable to water; that leads to less water filtration in depth, more surface water runoff and erosion. In other soil consistencies, such an impermeable layer, known as soil crust, is created when soil is not farmed.

In sloping areas, farming is difficult to be carried out and erosion, especially when farming is carried out in parallel with the longer slope of the field, is increased.

Impact in trees. It is certain that trees growing in non- farm soils have more roots and take advantage of the soil surface which is richer in nutrients (soil farming destroys a lot of surface roots). Thus, provided that there is no weed competition, trees that grow in non-farm soils, have higher growth in spring and usually yield higher numbers in fruits in summer. Due to higher growth and fruiting, trees in non farmed soils, in borderline situations and with limited water reserves in the soil may bear thirst symptoms in summer, because they strain their resources earlier than trees in farmed soils. For the same reasons, trees in non- farmed soils take direct advantage of possible rainfalls in summer and autumn.

It is also widely known that fruit harvesting in non- farmed (and with no weeds) soils is easier. Such a soil decreases tree damage risks by spring frosts, as bare soil performs more efficiently at night and exploits the heat it has absorbed during the day, rendering temperature decrease less abrupt in the lower levels of air.

On the other hand, non- farming along with the use of herbicides run the risk of damaging trees, if herbicides are not properly implemented. Also, due to the repeated use of herbicides, the plant community of weeds may change, susceptible species may decrease and resistant species may increase; thus, weed tracking and constant method adaptation are needed.

3.4.2.2 Other farming systems

Both of the aforementioned systems have weaknesses; therefore, a good choice is to use both in combination. Thus, various mixed systems have been developed, which give better results. Two such systems, which are used by quite a few olive growers in Mediterranean countries, are as follows:

1. Implementation of both systems in zones, non- farming in tree lines and farming in aisles among the lines. That is in zones (width according to tree canopy) along the lines, chemical farming with herbicide implementation is carried out. In parallel zones among the lines, conventional farming takes place (without herbicides). Undesirable weeds that are not controlled with the one or the other method are wiped out with local application of postmergerence herbicides (they should not be let uncontrolled, because they may expand throughout the whole field). With this system, we have non- farming and farming zones and thus, the pros of the two systems are utilized: non-farming close to the trees for bigger growth of the root system and farming at the aisles for more water retention. It is possible for the farming zones to be carried out in a cross shape or in a parallel and vertical on tree lined shape; thus, farming is restricted only under the canopy.
2. According to another freer mixed farming system, soil is cultivated throughout, but it confines itself to only a few (1-2) millings in the appropriate periods (more frequently in autumn and end of winter). At the same time, 1- 2 local applications of post-emergent herbicides for weed control in the crucial phases. Thus, if weeds make harvest difficult, a first herbicide application takes place (Roundup, Basta etc) before the onset of harvest. If harvest lasts more time, a shorter duration residual herbicide is applied (such as Goal). Weeds are left to grow in winter, because they are desired (frost affected areas are excluded) and are removed in the second milling or with a post-emergent pesticide by the end of winter, at least one month before the onset of the new tree germination period. In summer, due to drought, not a lot of weeds germinate. According to the number of weeds, a special post-emergent herbicide local application may be applied (for bindweeds and so on).
3. Another system that may be applied in areas with frequent rainfall in winter (more than 500-600 mm) is the man-made plant cover. According to this system, a selected plant (cereals or legumes) is spread in autumn, usually in lanes among tree lines. If the plant used is cereal, then extra nitrogen is provided (except for that provided to the trees). These plants are left to grow in winter and after a certain stage they are either incorporated in the soil (green manure) or they are dried with a post-emergent herbicide and are left on the surface. In a few Greek olive groves, there is natural green grass, which can be used in the framework of such a system. Such self-seeded plants that form pure green grass (oxalis, annual ryegrass and so on) are inhibitory to weeds, even after their drying due to substances they set free in the soil (reciprocal phenomenon).

As it is obvious from the above, there is no excellent farming system for all cases. The olive grower will have, in co-operation with the agriculturalist, to find the combination that, through means and methods, will give optimal effects with the lowest cost for his/her case. (soil type, farm type, as well as other special conditions).

3.5 IRRIGATION

The olive tree is considered to be the most drought- resistant tree. This notion has been established by the fact that in para- Mediterranean countries, the olive tree grows for many centuries now and gives the least moderate yields in dry areas with not many rainfalls (200-300 mm). Olive groves installation in such conditions, of course, is an emergency situation, as no other fruit plant is able to fruit in such infertile and dry soils. However, big sized cultivars olive groves that yield edible fruit have generally been installed in relatively more fertile soils and areas that have quite a few rainfalls or there is a possibility for irrigation.

Olives are adapted and resistant to dry conditions. This mostly happens in hot dry types of soils. Olive tree leaves are leathery and are covered on the upper surface by a thick cuticle that tends to keep down water losses from the tree; on the underside, leaves form minute white scales immersed in the tissues and are covered with dense fur.

With this construction, transpiration is restricted and leaves are protected from dry conditions of high temperatures and winds.

Despite the fact that they can grow in dry soils, olive trees, in order to pay off as a tree cultivation, need soil moisture, as other species of fructiferous trees do. Water shortage in the fruiting and setting period is one of the main reasons of the olive tree infertility. Soil moisture shortage during diversification and fruiting are of great importance. Low soil moisture during this period causes decrease in length and number of inflorescences. Also, soil moisture shortage causes atrophy of the pistil and this results in deficient formation of fruits. Soil moisture decrease during setting period affects tree growth. Reduced tree growth observed in dry areas has negative effects in next year's fruiting, as normal growth shortage deprives the tree of fruit organs, where next year inflorescences are formed.

Irrigation of the olive tree favors not only fruiting but the general situation of the tree growth, too. However, irrigation in dry areas greatly affects the olive tree, as irrigation water implementation not only brings about high yields, but also restricts the tree alternate bearing. In areas where rainfall is

reduced, irrigation during the crucial period of fruiting affects fruit setting positively. Irrigation in such areas should be implemented on time, so that during the period from flowering buds diversification to the time of setting, there should be soil moisture efficiency in the olive grove.

Irrigations during growing season affect new vegetation increase and fruit increase positively. In order to avoid fruit shrinkage, more water should be provided with irrigation during the warm season of July-August and September. Shrunken fruit gets its turgidity back after the early rainfall in autumn, but moisture deficiency may cause new shrinkage again and aggravate fruit quality.

Irrigation in edible olives is of great importance; irrigation implementation before harvesting during rapid fruit increase stage affects fruit efficiency and quality positively (adequate size for canning).

Irrigation frequency depends on the tree growth, the growing stage, the season and soil-climate conditions prevailing in the area. Olives need more water during the periods of high droughts (August and September). This period that clashes with the period of the endocarp fruit period (pit), fruit is in the expansion phase and moisture lack restricts its growth.

The period before fruiting up to setting is also crucial. Usually, during this period, soil contains enough moisture reserves, derived from the winter rainfalls, but in dry areas, where rainfalls are reduced, it is possible for soil moisture shortage to appear.

Water taken by the roots is mainly used for the tree transpiration needs. Transpiration is affected by soil moisture, sunlight, temperature, atmosphere moisture and wind. Trees of a larger size use much more water in relation to small- sized ones, due to their larger foliage surface. Growing size slightly affects the irrigation needs, since the larger quantity of water is used by leaves. The olive tree, in contrast to deciduous fruit trees, needs soil moisture during the whole year. In winter, however, water needs are restricted.

Irrigation frequency in the olive grove may be determined with tensiometers. The appearance of weed withering is an indication for the moisture condition. In areas, where mallow and melilotus grow, these plants can be used as moisture indicators and the olive grove can be irrigated when these plants start withering.

The irrigation system, which is used in slightly tilted soils and where irrigation water is available, is basin or ditch irrigation. Sprinkler systems are also widespread and are recommended for inclined rough terrains. In areas where there is irrigation water shortage and areas with inclined terrain, the drip irrigation system is recommended. Despite the high cost of installation of this system, it is widespread in

our country and this is due to water economy achieved in dry areas. The system is perfectly combined with herbicides in inclined soils, where ploughing or construction of terraces creates problems to the crop.

In soils with uneven topography, plant cover of the soil helps the olive grove maintain its soil constitution, facilitates the absorption of rainfall water and hinders soil erosion. Weed grasses (derived from natural growth of weeds) are checked during the months of the growing period; legumes are sowed (fava beans or vetch) and are cut or removed on time. In this way, nitrogen content is increased in the soil.

When substrate water level is high, olives do not grow adequately. Olive trees in such soils usually have dead branches, yellowish leaves, low yields and their fruits have an early ripening period. These trees, being under permanent moisture excess, die in time.

3.6 SOIL FERTILIZATION

The olive tree is one the most important tree cultivations in Mediterranean countries, which takes advantage of soils, where only a few fructiferous trees can grow. The tree grows and bears fruits in a great variety of soils, from lowland deep fertile to relatively dry, poor, pebbly and quite often calcareous soils of hill and mountainous areas. The fact, however, that the olive tree bears fruits in such poor soils should not give the wrong impression that soil does not have needs and that the tree needs in nutrients are very low. The tree gives yields rich in fruit in deep sandy-loamy soils, which are rich in moisture, yet with good drainage. Low yields in olive groves in many areas of our country are due to shortage in nutrients from the soil. Also, early aging of many olive groves are due to shortage in nutrients, mainly nitrogen (N); this is caused with the frequent farming with no fertilization of the soil. The olive tree grows both in acidic and alkaline soils. However, the most adequate soils are those which have a pH from 6.2 to 8. In lower or higher soil acidity values respectively, growth restriction is even higher. The olive tree is more soil salt tolerant than other fructiferous trees.

Each and every olive tree withholds a quantity of nutrients, which it uses both for its growth and fruiting period. For a stremma, the quantity of nutrients that trees absorb from the soil in a year is: 1.5 up to 3.5 kg for N, 0.8 up to a kg for P_2O_5, up to 5 kg for K_2O and 2 up to 5kg for CaO. (Morettini, 1950, from Sfakiotakis, 1987). These nutrients should return to the soil in the form of fertilizers, so that soil is kept in a good fertility condition.

3.6.1 Demands in Nitrogen

Nitrogen is a primary plant nutrient for the olive tree, as well as other fructiferous trees. This nutrient greatly affects tree growing and fruiting. The olive tree reacts favorably in nitrogen fertilization, especially in soils with reduced fertility and when soil moisture is a very restricting factor. Nowadays, high yields in olive producing areas are achieved only with the dispensing of rich nitrogen fertilization in organic or inorganic form. It has been proven through numerous experiments in olive groves around the globe that the value of nitrogen fertilization is priceless, when it comes to high yields. High yields are caused due to the positive reaction nitrogen has in fruit setting and the formation of fruiting bodies for next year. Nitrogen fertilization affects positively not only the fruit yield of this year, but of the next year, too, minimizing the alternate bearing of the tree. Excess nitrogen fertilization, however, may cause excessive fruit setting. This fruit is small- sized and has a late setting period.

In cases of nitrogen shortage, not only yields are reduced, but also growth is restricted. The main symptom of nitrogen shortage is annual vegetation shortage. Leaves are smaller in size and light green-coloured, in comparison to the leaves in nitrogen adequacy, which are larger and deep green-coloured. They become yellow and they fall off the tree early.

In the table below, the absolute nutrient- content values, which are used as indicators for tree nutrient condition diagnosis, are mentioned. Leaves are received from the middle of the last vegetation (5-8 years old) in winter.

Table 4: Absolute nutrient- content values on olive tree leaves (Source: Gavalas, 1978, from Sfakiotakis, 1987)

Per cent in dry matter **Nutrient**	**Deficiency**	**Relative deficiency**	**Desirable condition**	**Excess**	**Over-abundance**
Nitrogen (N)[1]	<1.20	1.20- 1.60	1.60- 1.80	1.80-2.20	> 2.20
Phosphor (P)[2]	< 0.07	0.07 -0.09	0.09-0.11	0.11 -0.14	> 0.14
Potassium (K)[3]	< 0.50	0.50 0.70	0.70-0.90	0.90-1.10	> 1.10
Magnesium	< 0.07	0.07-0.10	0.10-0.30	> 0.30	> 0.30
Calcium(Ca)	< 0.50	0.50-1.00	1.00-2.5	> 2.5	
Sulfur (S)	< 0.05	0.05-0.10	0.10-0.25	> 0.25	
Chlorine (C1)			0.10-0.40	0.40 – 0.80	> 0.80
Parts per million (ppm) in dry matter					
Iron (Fe)		20-50	50-150	150-500	
Manganese(Mn)		5-20	50-150	150	
Boron (B)	< 15	15-20	20-50	50-150	150
Zinc (Zu)		5-10	10-30	30	
Copper		<5	5-20	20	
Molybdenum(Mo)		< 0.03			

a. Excellent N/100 ratio of the total nutrition in N+ 10P +K =46-52

b. Excellent total nutrition N% + 10%P + K% =340- 360

a. Excellent 10P/ 100 ratio of the total nutrition in N + 10P + K = 25-31

a. Excellent K/100 ratio of the total nutrition in N + 10P +K = 20-26

In poor coppery soils, which are deficient in organic matter and nitrogen, trees react intensely in nitrogen fertilization. In such soils, however, nitrogen is washed off easily with rainfalls. On the contrary, in fertile deep soils, which have enough organic matter, nitrogen is more stable and is washed off less by water. In those soils, there is enough nitrogen to cover the tree needs with for a few years, thus tree reaction in fertilization is not so intense.

For the determination of fertilization needs in nitrogen, various factors are taken into consideration, such as the nutritional status of the tree, the available soil moisture, the age and planting density. Monitoring the nutritional status of the tree is carried out with leaf analysis. Olive groves, which are monitored through leaf analysis, the annual nitrogen fertilization must be adapted in such height that leaf content in nitrogen during winter should be kept within 1.60%-1.80% (Gavalas, 1978, from Sfakiotakis, 1987). Other researchers demonstrate other values. Such nitrogen levels are often achieved in doses, which do not exceed 1 up to 1.5 Kg N/tree or 10-15 Kg N/stremma. In densely planted olive groves, fertilization should be carried out according to stremma estimation. Because of the fact that soil moisture, which depends on the area rainfall and the irrigations, is a crucial factor in fertilization determination. In areas with reduced rainfall (annual rainfall 400 mm), we observe conditions of reduced reaction to nitrogen fertilization and, for this reason, fertilization is recommended to be restricted (100 gr N/tree / 100 mm of rainfall height or 1 Kg N/ stremma /100 mm of rainfall). On the contrary, in areas with high rainfall, from 400 up to 700 mm annually, since the restricting factor of reduced soil moisture does not exist, trees react better in nitrogen fertilization and for this reason doses of 150 gr. N /tree/100 mm of rainfall are recommended. In areas with rainfall height over 700 mm, nitrogen level should not exceed 1.5 Kg N / tree or 15 Kg N/stremma.

Nitrogen is dispensed in the form of manure or as one of the nitrogen fertilizers. Manure is provided early in fall, because it frees nitrogen in trees in a slow pace. Inorganic chemical fertilizers are dispensed in December or January, so that nitrogen is available in the beginning of March up to June, which is the most crucial stage of diversification and change of flower buds to flowers. After fruit setting, nitrogen

abundance enhances vegetation which is crucial for the fruiting of next year. For dry olive groves, nitrogen fertilization is carried out in December up to February, while for irrigated olive groves, if fertilization is provided in one up to three doses, the results are better.

3.6.2 Demands in Phosphor

It cannot be doubted that phosphor is a crucial factor for tree life. It is a constituent element of many organic substances of the plant, which participate in DNA and RNA cell composition. The importance of phosphor as a fertilizing element seems to be greater in annual vegetations rather than arboraceous vegetations. This is mainly due to the fact that trees have an extended root system that takes up a large space and can absorb the necessary quantities of phosphor every year. For this reason, a lot or researchers believe that the olive tree rarely suffers from phosphor deficiency and that the cases where the olive tree reacted in phosphor deficiency are rare.

Phosphor deficiency symptoms have been described from experiments in growth of young trees in sand with nutrient solutions. A characteristic symptom of phosphor deficiency is mottled chlorosis of leaves (motley leaves) and vegetation restriction. Chlorosis appears first in new vegetation and is usually accompanied by necroses on top and around the foliage. A lot of the chlorotic leaves fall off early.

The cases where trees reacted in phosphor fertilizations are only a few and for this reason, there is the prevalent opinion that the olive tree can easily cover its needs in phosphor from the soil reserves and that it does not need phosphor fertilization. It seems, however, that the importance of phosphor fertilizations is great in those cases, where phosphor deficiencies have been observed.

Nutritional status monitoring is carried out and other nutrient elements are examined too through leaf analysis. The usual leaf content in phosphor ranges between 0.90% up to 0.2% in dry material. As a desired phosphor level in leaves, the prices of between 0.09% up to 0.11% are recommended. Very low values, that is 0.03% up to 0.05% have been reported in cases of phosphor deficiency in the field, while very high content values in phosphor (P = 0.19 – 0..31 %) have been reported in young trees that grew in nutrient solutions.

3.6.3 Demands in potassium

Potassium is, as nitrogen and phosphor are, an element of great importance when it comes to the nutrition of the olive tree. It is used by the olive, as well as by other plants, in big quantities. This element is necessary for the implementation of numerous plant operations, as in photosynthesis, protein and starch synthesis, protein and sugar transfer, plant water balance, root system growth, and so on. Big potassium quantities are removed every year from the soil, both through the fruit which is harvested every year and through leaves and branches which are cut through tree pruning.

The removal of such big quantities of phosphor from the soil does not always mean there is potassium fertilization need. Many soils, especially deep lowland of average consistency soils, are rich in soil reserves which give big quantities of absorbable potassium in plants. Moreover, the olive tree, as other fructiferous trees, has a rich root system; thus, it takes advantage of large spaces in soil and can secure the potassium quantities needed for its nutrition. In deep lowlands, where rainfalls are frequent, we rarely see cases with phosphor deficiency in olive groves which are cultivated for many years. However, in shallow, poor, calcareous soils with a high inclination that receive only a few rainfalls, the satisfying growth of the root system is hindered, or in soils that have been recently formed by extra soil, cases of potassium deficiency have been observed in many olive growing areas of our country.

Potassium deficiency is manifested with characteristic symptoms, mainly with leaf chlorosis, which is accompanied by drying of the top of their foliage. The transfer of colour from green to chlorotic is done gradually, without leaving a clear borderline between green and chlorotic tissues. Characteristic is the colour of bronze that chlorotic tissues get. In advanced stages of deficiency, leaves grow small and fall off early. If symptoms are repeated for 2-3 years, branches lose their foliage and dry out. Potassium deficiency causes yield reduction, as a consequence of restricted vegetation and the small size of fruits; also, reduction in oil content of the fruits is observed, too.

The nutritional status of the tree from the potassium deficiency symptoms is not always a safe way. Similar symptoms may be caused by other reasons, too, such as chloride toxicity, boron phosphor deficiency and so on. Diagnosis from deficiency symptoms is carried out in advanced levels and, quite often, we have yield efficiency reduction long before the symptoms appear. The safest way to diagnose potassium, as well as nitrogen deficiency, is leaf analysis. With the method of leaf analysis, it is possible to detect those olive groves, which are in deficiency and with the implementation of potassium

fertilization, they may become more productive. In olive groves with high yields, the desirable potassium values on leaves are between 0.70 up to 0.90% and potassium fertilization is not recommended, except during years of high yields, where the quantity of potassium provided is the same as in nitrogen.

In olive groves, which appear potassium deficiency symptoms, leaf content is less than 0.30% and needs a very intense dose of potassium fertilization for the cure of deficiency. Fertilization is recommended to be carried out during the first year, rating 3-10 kg K2O/ tree or 30-100 kg/ stremma for the cure, then fertilization maintenance is recommended. Olive groves with no potassium deficiency symptoms (where potassium values are 0.30% up to 0.50%), intense potassium fertilization with 2 up to 5 kg K2O per tree or 20-50 kg K2O per stremma is recommended. Last, for 0.50% up to 0.70% leaf content in potassium, maintenance fertilization is recommended every year with potassium quantity equal or double the nitrogen quantity that is used for nitrogen fertilization. In cases with content over 0.90%, no potassium fertilization is recommended.

Due to potassium and nitrogen interaction, trees suffering from potassium deficiency usually have increased magnesium content in their leaves. Those trees' bad condition and low yields are mainly due to potassium deficiency rather than magnesium toxicity. After all, the risk of appearance of magnesium deficiency by intense potassium fertilization is not so serious in the olive tree, as in other tree cultivations.

Potassium and phosphor fertilizers are administered in autumn, with the onset of rainfalls and are incorporated as deep as possible in the soil and preferably around the area covered by the canopy shade.

3.6.4 Most common deficiencies

Except for potassium deficiency, which is quite common, Greek olive groves suffer from deficiencies related to micronutrients deficiency, the most common of which are:

3.6.4.1 Boron deficiency

It is one of the most common and serious deficiencies of the olive tree in Greece. It is observed both in young and age- long trees.

The most characteristic symptom of boron deficiency is that the tip of the upper leaves in new buds (the section 1/3 – 2/3) is chlorotic (primarily green- yellow and then yellow- orange). Gradually, this symptom appears at the leaves of the buds base, which may bear drying tips. In a more advanced deficiency level, we may see small leaves, leaf deformation (in the shape of a club) and intense defoliation. On branches where symptoms of the leaves are apparent, if a thin layer of the bark is removed with a dagger, someone can observe a brownish colour, which is due to cambium necrosis. This symptom is characteristic and confirms boron deficiency.

Thus, trees suffering from boron deficiency look like chlorotic, if seen by distance, and the onset of their flowering season delays significantly in spring. In more serious cases, new buds, except for the leaf chlorosis mentioned above, exhibit necrosis of their tips, unfolding of side buds, which can also be deadened and, in general, the tree may gradually exhibit dead branches on the canopy.

Also, very intense fruit falling is observed in summer. In very serious cases, the tree does not produce flowers, but only wood buds, which results to annihilated yields.

The symptoms above are a serious sign that the tree suffers from boron deficiency. However, they might be due to other reasons, too (Verticillium wilt, phloephagus attacks, various nutrition disorders, etc); for this reason, confirmation through leaf analysis must be carried out. Leaves suffering are of a boron content less than 20 ppm, while healthy leaves are of a boron content more than 20 ppm (in their dry material).

For the cure of boron deficiency, borax fertilization is implemented in winter. 300- 500 gr of borax are added to the soil per tree in full growth, while in younger trees, smaller quantities are provided (10 gr per age year, since it was planted in the field). Borax administration should be repeated every 3-4 years preventatively in a dose of 100-150 grams / tree. In case of disease appearance in only a few trees within the olive grove, borax should be provided to all trees, because it is most possible that all trees are on the brink of shortage. However, borax should not be provided to olive groves, which are not borax deficient, as it is particularly toxic.

For a quicker reaction of the trees, water- soluble form of borax (Solubor and so on) may be used through foliar application or through the irrigation system, if available.

3.6.4.2 Calcium and magnesium deficiencies

Less common are calcium and magnesium deficiencies.

The main symptoms of calcium deficiency are chlorosis of the tip part of the leaf, as in boron deficiency, which is combined with nerves bleaching in the area of the chlorotic part of the old leaves.

The characteristic symptom of magnesium deficiency is leaf chlorosis which starts from the top or the side of the leaf blade and which gradually takes up the whole surface; as a result, we have intense defoliation and poor vegetation.

Deficiency adjustment is carried out with the addition of 5- 10 kilos of calcium oxide or marble dust per tree. However, calcium deficiency problems should be prevented. The most proper and most permanent methods are pH determination before the olive grove installation and soil liming after chemical analysis.

Magnesium deficiency is dealt with the addition of 300- 500 grams of magnesium oxide (eg 1.2-2.0 kg/ tree kieserite or 3.0- 5.0 kg magnesium potassium sulfate that contains calcium too for simultaneous with this element fertilization) or with tree spraying with 2-4% water- soluble potassium sulfate solution.

3.6.5 Fertilizers used

3.6.5.1 Nitrogenous fertilizers

Nitrogenous fertilizers most frequently used in olive trees are the ones mentioned below.

Ammonium sulfate. It comes in two forms:

Crystalline (21 -0 -0) and

Granular (20.5 -0 -0)

Ammonium sulfate is adequate for calcareous – alkaline soils, in which, due to the pH reduction in root surface, increases phosphor and trace elements solubility (iron, zinc, etc). Its use is not recommended in acidic soils.

The granular form is offered more particularly for mechanic dispersion with spreaders.

For the avoidance of big losses from ammonia volatilization, it is recommended its application to take place through incorporation within the soil (milling).

It contains nitrogen in ammonium form, which is not washed off of the soil easily. It becomes available to the plants, mainly during gradual conversion in nitrogenous form, a few weeks after the application. Thus, it has a satisfying residual activity and is offered for fertilization early in the season.

Ammonium nitrate. It comes in granular form with nitrogen content 33-34.5% (33.5-0-0 or 34.5-0-0 and more).

It is very soluble in the soil and with minimal moisture, it provides nitrogen to the plants in nitrate and ammonium forms.

Nitric nitrogen, which is directly absorbable by the plants, is not retained in the plants, and the quantity not absorbed by the roots is rinsed towards the subsoil and the water table and it is dispersed in the environment polluting it. Ammonia nitrogen, on the contrary, is retained to the soil and becomes gradually available to the plants in a few weeks. It has a less residual action than ammonium sulfate.

This fertilizer has got acidic properties and its use should be avoided in alkaline soils and humid areas, even in neutral soils.

Calcium ammonium nitrate. It is available in a granular form and is a mixture of ammonium nitrate and calcium carbonate, with a nitrogen content of 36- 28%. It is offered for use instead of ammonium sulfate or ammonium nitrate in acidic soils, as well as in humid areas for the avoidance of soil acidification.

Ammonium sulphate nitrate. It contains ammonium sulfate and ammonium nitrate, usually in a 4:1 ratio, with 24-30% nitrogen content. It has an intermediate residual action and because of the fact that it is of low hygroscopicity, it is offered as an easy solid mixture with other fertilizers.

Urea. It is water soluble and contains nitrogen in organic form (45-46% N). From the soil, it is a source of slow pace nitrogen (as it must be modified to ammonia in order for it to be assimilable) and this restricts nitric nitrogen losses from rinsing. In the soil, it has an oxygenous reaction, while in calcareous soils, losses are very intense due to ammonia volatilization. For the avoidance of those losses, urea should be administered through direct assimilation or irrigation application straight after dispersion or through water fertilization. It is recommended for the olive tree for added nitrogen fertilization through foliar sprayings, as well as for trace minerals absorption assistance from the leaves.

In order to avoid toxicities in cultivations, ureas impurities should be lower than 2% for urea implementation from the soil and lower than 0.25% for foliar application.

3.6.5.2 Potassic fertilizers

The potassic fertilizers above are usually used for the olive tree.

Potassium sulphate. It is provided in a dust or granular form for soil implementation and in a crystalline form (water soluble) form for water fertilization application or foliar sprayings. It contains 48- 50% K2O and around 17% S.

It has a low salinity index and is recommended for soils with salt problems. For application through water fertilization, there is the disadvantage of the slow dissolution in temperatures lower than 20° C.

Potassium nitrate. It is provided in a crystalline or granular form. It is very water soluble and is offered especially for application through water fertilization or foliar sprayings.

It is a source of potassium (46%) as well as nitric nitrogen (13% N).

Magnesium potassium sulphate (Patentkalli). It is available in a granular form for soil application. It is a source of assimilable potassium, magnesium and sulphur. It contains 30% K2O, 10% MgO and 20% S.

3.6.5.3 Phosphatic fertilizers

For addition to the soil, the above fertilizers are recommended:

Superphosphate (type 0- 20-0) or

Triple superphosphate (type 0-46-0), which are available in a granular form.

For application through water fertilization, crystalline water soluble fertilizers are recommended:

Monoammonium phosphate (type 12-61-0) and

Diammonium phosphate (type 21-53-0).

3.6.5.4 Boron fertilizers

For the prevention and cure of boron deficiency, borax can be added in the soil or various soluble forms of boron that are available in the market (Solubor, Boro Plus, and so on) may be applied through water fertilization or foliar sprayings .

3.6.5.5 Compound or mixed fertilizers

A big number of complete fertilizers are available in the market and contain two or three basic elements (nitrogen, phosphate, potassium), which may be enriched with boron or other trace elements. Olive tree growers who want to use such a fertilizer should chose the one that its composition (type) matches the ratio of nutrients they want to apply during fertilization.

A serious disadvantage of compound fertilizers is that the application of all three elements (N, P, K) is obligatory during the same year, while it is accepted that potassic and phosphatic fertilizers should be applied in autumn and nitrogenous ones in the end of winter, so that their maximum utilization is achieved.

3.7 OLIVE TREE PRUNING

Olive tree pruning, as in other fructiferous trees, affects tree flowering and fruiting. Pruning is one of the most important farming cares, as it helps the olive grove adapt better to the productive conditions of the area. Thus, the tree that receives the adequate pruning adapts itself and bears high yields in any soil climate condition. Usually, canopy growth is restricted in dry and infertile soils, while it grows better in fertile and irrigated soils. Also, pruning helps crops get adapted better in today's financial- technical conditions of our country. Many problems, related to the oil high production cost and most importantly the fruit harvesting, may be dealt better through the selection of the proper tree growth form. Thus, fruit harvesting mechanization which is a problem for olive tree growers seems not possible to be accomplished, only after we apply the appropriate forms for vibrator harvesting. In the last years, man labour shortage, which is observed in the olive producing areas, led producers to the implementation of new systems of canopy formation, either on a level (palmetto), or on low forms which permit dense plantations and are better offered for harvesting straight from the soil. Fruit pruning which is applied to other fructiferous fruits (peach tree, apple tree, and so on) comes out costly, especially for olive producing trees.

3.7.1 Pruning aims

Olive trees are pruned in three ways, according to our target:

Formative pruning in young trees, aiming to create a strong trunk and a formation that will meet our expectations (olive harvesting).

Fruit pruning, in order to ensure the stable yields and fruit good quality (table olives) as much as possible.

Renewal pruning in old-aged trees, to avoid exhaustion of canopy production throughout the years and to restore trees in desirable shapes and sizes.

3.7.2 Formative pruning

The necessary interventions are implemented, so that trees, after the first years of their growth, may take a form that helps farming activities be carried out, (sprayings, and more importantly olive harvesting). During this phase, interventions (strict pruning) must be avoided, as it delays the tree entrance into the fruit season.

A common shape that is given to the trees in Greece is 'free cup'. For the formation of this shape, young trees are in a height of 60-80 cm above the ground during replanting. In the first year, the creation of side buds is aimed in normal distances around the trunk and in a height of 30-60 cm from the ground. In the next years, the tree is slightly pruned, only for the removal of any 'voracious' weeds from their base substances and the removal of broken branches and branches intersecting among them. Since the tree grows adequately, 3-5 basic branches are selected from the trunk with a distance of 20-30 cm among them and then the central bud is removed. After the tree entrance in the fruit period, since strict pruning is not carried out, the tree gradually takes a free round shape.

For intense planting systems, where dense planting is implemented, low formation shapes are used, the most important of which are 'low cup shape' and 'bush shape'.

In low cup shaped formations, embranchment is formed in a distance of 30-40 cm above the ground.

In bush shaped formations, no pruning intervention is carried out during the first 5-6 years and then, only debilitated buds and the tree tops that reach in height more than 3 metres are removed. For the achievement of this shape, planting of cuttings by ovules that bear a lot of buds from very close to the ground should be implemented or more young trees (2-5) in each location should be planted.

Bushy shape has certain important advantages for intense farming:

- Trees start entering the fruiting period faster.

- They bear higher average yields in stremmas compared with other shapes.
- They make olive harvesting stronger without ladders, minimizing the harvest costs.

Both the bushy shape and the low cup have the disadvantage that they hinder soil mechanic farming and also make fruit harvesting from the soil almost impossible. An improved low shape, without the aforementioned disadvantages, is the low cylinder one with a single trunk and intermediate low branching crown.

Since, during the study of a new olive grove installation, it has been decided that the olive oil production, during productive years, will be carried out with the use of mechanic trunk vibrators, the proper shape of trees should be formed from the beginning. In these cases, the cup shape is usually selected, which will have to be altered, so as to include the following characteristics:

- Tree plantation should be denser than 6x6 metres.
- Canopy will consist of 3-4 branches in straight position (inclination should be around 40° as to the horizontal level).
- The trunk should be at least 100-120 cm and the tree height up to 3-4 metres.

In the systems of very dense linear planting, where mechanic harvesting with the altered grape collectors is applied, tree formation usually takes place in a shield or conical shape (cypress-type), where there is a central arbor with short branches across it.

3.7.3 Fruit pruning

For successful fruit pruning, knowledge on how the tree fruits and pruning experience are important. The olive tree bears fruits on moderate vegetation last year buds, which are located in the illuminated peripheral zone in 60-80 cm depth of the tree. Only a few fruits are formed in this zone, close to the trunk or their branches. Moreover, very vigorous buds are not fructiferous (they only have flower buds), while weak buds give only a few fruits (a few fruit buds). Thus, the aim of fruit pruning is the creation of medium-sized buds (15-50 cm) and the preservation of the fruit zone in adequate vigorousness and with adequate lightning).

The aims above are difficult to be achieved in densely planted trees that are shaded by each other. In this case, the fruit zone is restricted on the tops of the trees and in some points on their south side, where they are shed by light. In those trees, when their tops are cut for tree lowering reasons, their yield efficiency is reduced a lot, because an important part of the fruit surface is removed.

In normal, productive trees, a light fruit pruning with the removal of the dense and dead branches from the fruit zone is recommended to be carried out. This happens due to the fact that the fruit zone tends to become dense and full of small buds. By implementing the pruning above, the length of buds is improved and adequate illumination is achieved in the fruit zone. This kind of pruning must be stricter in trees growing in infertile and dry soils, so that the foliar surface is restricted and food and water are saved for the new fruit vegetation. On the contrary, pruning on trees which grow in fertile soils or are fertilized and irrigated should not be strict, as there is no food and water adequacy both for the already existed fruiting, as well as the new fruits. In the last case, strict pruning gives voracious fruits that enter the fruit season late.

Fruit pruning in table olives, if carried out properly, may improve the fruit size due to the achievement of load control. For this reason, thinning out should be carried out during the years of excessive fruiting, slightly after fruit setting.

Proper pruning may also decrease biennial bearing effects. For this reason, strict pruning is recommended (with the removal of buds of moderate vigorousness that most possibly will turn into flower buds) in the winter preceding the year of high yields. On the contrary, strict pruning that is usually carried out after harvesting in years of high yields, deteriorates biennial bearing effects (it exhausts the already exhausted from the fruit season trees even more).

3.7.4 Renewal pruning

The olive tree has the ability to re-grow from whichever part of the wood after cutting and this characteristic is where its longevity lies. Due to this ability, the renewal of old-aged trees, as well as the restoration of trees that were damaged by frost or fire are possible.

Old- aged trees of low yields are renewed with trunk beheading low or in the place of enbranchment (cross). Bare branch whitewashing should be implemented, so that sunburns are avoided.

For canopy partial renewal or restriction in shaded densely planted trees, branches or the first branch crossings are cut in equivalent height. Sometimes, pruning may be restricted in some branches that have grown high to achieve tree lowering. In these cutting parts, new vigorous buds from which the most appropriate ones are selected for the formation of the new tree structure grow. In all these cases, tree enters the period of normal fruiting 3-5 years later.

In order to restore trees afflicted by frost or fire, trees are left to rest for a year so that the real damage to become apparent. From the new buds which, in the meantime, grow, new branches of the tree will be formed, while all damaged parts are removed.

3.8 FRUIT THINNING OUT

During the years of high fruit setting, fruit thinning out can be applied to the olive tree, as to other fructiferous trees, too. Through thinning out, parts of flowers or fruits are removed and excessive fruit setting is avoided, as it results to the tree nutrients exhaustion, the small size of fruit and the biennial bearing effects of the tree. Thinning out aims the following: 1) bearing effects decrease, 2) improvement of fruit size, 3) earlier yield production, 4) higher oil content, 5) higher flesh/pit ratio, 6) reduction of fruit harvest cost, 7) restriction of branch breaking due to excessive load, 8) creation of new vegetation for next year fruiting season, and 9) higher yields for some years.

Fruit thinning out is not always implemented, and practically, it is only applied in edible olives, as it has the disadvantage of high cost when carried out by hands and also because it restricts the total tree production during the year it is applied. The increase in size does not always bring reduction in production from the fruit removal through thinning out; thus, higher prices should be ensured in edible olives that stay on the tree, so that fruit thinning out can be efficient. Generally, however, fruit thinning out of the olive tree is not economically advantageous, unless trees are very loaded. In edible olives, every 20 cm of the annual bud should bear 3 up to 5 fruits, according to the tree age and vigorousness.

3.8.1 Ways of pruning

Thinning out with hands. Thinning out with hands should be carried out as early as possible, in order to achieve the targets mentioned above. This period, from mid- June up to mid- July is recommended as the best season for thinning out to react and for biennial bearing effects to be restricted. Late thinning out, while it reacts positively in the increase of fruit size, it reduces total yields. Thinning out by hands is made easier with the use of gloves. Usually, both hands wear gloves and simultaneously draw many branches from the base along the top and residual fruits are removed. Only branches from which, in one go, at least 5 up to 6 fruits are removed, are thinned out. Thinning out by hands is a great disadvantage of high cost and is rarely used in practice in small olive groves with edible olives.

Chemical thinning out. The most cost-effective way of fruit thinning in the olive tree is with hormonal preparation. Spraying with naphthalene acetic acid (NAA) has brought really good results in California and other countries, too. NAA is used in a ratio of 150 ppm by mixing it with a detergent. Best results are brought about when spraying is applied 10 to 18 days after full flowering.

Spraying time is very crucial and is determined by the fruit size. With the collection of 150 ppm NAA, spraying is recommended to be applied when the small fruit diameter ranges from 3 to 5 cm. The hormone is absorbed by the other leaves and parts of the tree and moves towards the fruits, where it causes the formation of a layer cut in certain fruits. The results of the hormone's action may be affected by various factors that facilitate or inhibit the absorption of auxin from the leaves. Very high temperatures (over 38 °C) of the air during sprayings or straight after sprayings increase the diluted action of the substance. Spraying is greatly affected if it is applied on trees with reduced soil moisture. Chemical thinning out is more efficient in overloaded trees and intensifies the fruit fall in June. For the reasons above, chemical thinning out must be implemented only in those cases and cultivars, where much experience has been attained.

NAA is also used successfully for the perfect fruit removal, when the olive is used for cosmetic reasons and is aimed for cleanliness reasons or full fruitlessness of the tree.

3.9 HARVESTING

Fruit harvesting is the most cost-effective activity in olive production. Its costs depend on the exploitation system of the olive grove, the cultivar, the way olive fruit is harvested and yield efficiency. In general, the bigger the trees are, the more restricted yields are and the more restricted yields are, the more increased the harvesting costs are. From the total production costs, it is estimated that at least 50-70% covers the harvesting labour.

Olives are harvested after they have reached the proper stage. The fruit goes through various colour stages: green, pale green, rose, violet, black and fully matures 7-8 months after flowering. In edible olives, in which weight increase is of great importance, harvesting is carried out after increase is completed and fruit starts changing colour. It should be taken into consideration that harvesting should definitely have been carried out slightly before good qualities of fruit flesh start to degrade, something which is of great interest for tinning. More table olives are harvested in our country in the end of September up to mid- November, depending on the cultivar and the climate conditions that prevail in the area. Green olives are harvested in the end of September up to the beginning of October, when

fruits are immature, but they have obtained their definite size. Black edible olives are harvested slightly later, in November- December, when the fruit is blackened, but before it starts to soften.

Olive oil olives are harvested fully ripe. The most suitable season is when the fruit acquires the largest size and the oil formation has been completed. This stage depends on the cultivar, the climate conditions and the cultivation cares implemented.

Fruit oiling, which is of interest in the olive oil olives, starts in August, slightly after the pit's hardening and increases gradually until the fruit is blackened. In 'Koroneiki' cultivar, which is cultivated in large areas in southern Greece, fruit oiling increases in a quick pace up to the last two weeks of November and then follows a small increase up to mid- December , when oiling has been completed.

More practically, in order to determine the harvesting time, we bear in mind other factors too, such as risks from dacus attacks and harvesting escalation that the producer is obliged to do, in order to ensure the necessary man- labour and the smoother processing of olive farm activities. Also, the producer should not neglect the impact that harvesting time has in the fruiting of next year. Harvest delay for better fruit oiling is considered to have negative effects in diversification inflorescences of next year.

Table cultivars are harvested by hand or with the help or special rakes. Harvest by hand is carried out with fruit plucking from the fruiting bodies. The fruit is thrown carefully on spread fabrics or plastic nests. In large- sized cultivars, the fruit is thrown carefully in baskets, in special bags or in baskets coated internally with fabric. Fruit raking is carried out with special rakes that facilitate the activities. Fruit treating is carried out with caution, because the slightest scratch on the fruit skin is visible after the fruit processing and product quality is reduced.

Olive oil olives are harvested in different ways, depending on the cultivar and the farming system implemented in the area. In many areas of the country, pole beating is used. In this method, labourers beat the branches with poles, when fruits reach the appropriate stage of ripeness and are dislodged easily. Through pole beating, except for the fruit, many leaves fall off too and fruitful buds break. In some cultivars, such as in 'Koroneiki', these damages may cause the tree to appear bacterial, especially in wet weather. Through pole beating, the fruit falls off on the ground or on fabrics. In other areas, for cultivars not easily dislodged from the tree through pole beating ('Chondrolia Kritis'), the fruit is left to fully ripe and fall off naturally on the soil, where it is selected from.

Picking up from the soil is made easier after weed leveling and cutting. In areas, where lack of labour is observed, harvest is carried out in a very slow pace and the oil quality derived from such olives

(chamades) is degraded, because fruits are mixed during rainfalls with foreign matters (mud). Fruit picking from the soil is made easier with the use of needle rollers and plastic nests. Through the movement of special rollers on the ground, all the olives are pinned on the needles, from where they fall in a receptor. In order for the machine to be effective, though, olives should not be small- sized and the ground should be appropriately prepared. The fruit should not stay long after harvest, because due to the fruit injuries, there is the danger of oil oxidation and quality degradation. In such areas, plastic nests are mostly widespread, the use of which, even if a lot of money is required, tends to be established as a way of olive harvest. Those nests continuously stay spread under the trees or as long as the fruit setting last and allow, independently of weather conditions, quick picking of fruits in many "hands".

In many countries (US, Italy), mechanical harvesting is implemented with vibrators and this reduces costs. In contrast to other fructiferous species (nuts, plums, etc), crop mechanical harvesting in olive trees is harder and has several problems, due to the way the tree fruits and the non-uniformity in ripeness of fruits of various cultivars. The way the tree fruits, which tends to form infructescenses far from the branches, creates problems and difficulties in transmitting the dislodging power of the fruit with the same intensity in all fruiting organs. Efforts are made to moderate non- uniformity in fruit ripeness that characterizes most cultivars with the use of fruit-falling substances that reduce the fruit dislodging power. From the fruit-falling substances, commercial formulations, such as Ethrel and Alsol, that produce ethylene when sprayed on the tree, were used (Hartmann et al,1970 – Hartmann et all, 1976). From the fruit- falling substances, Ethrel, except for losening in fruit adhesion of fruiting bodies, it causes intense defoliation, which may have negative effects in the production of next year. Alsol, which attracts ethylene in less time, seems to give better results, because it causes fruit falling without intense defoliation.

Various reasons affect fruit dislodgement, as vibration frequency, the time vibration takes place, as well as the fruiting bodies species.

Mecahnical harvest implementation in our country deals with a lot of problems, especially in the already formed olive groves with cultivars that the producer cannot easily change and a tstructure that is not easily compatible with vibrator types available in the market. We have to deal with extra difficulties in the olive groves installed in very inclined soils, where vibrator movement is hard. New olive planting shapes that are widespread in our country with bush shaped growth does not seem to be appropriate for mechanical harvest.

3.10 THE OLIVE TREE ENEMIES AND DISEASES

Many insects and diseases afflict the olive tree and cause various tree and production damages. In order to deal with those damages effectively, either early (preventive) control of those damaging factors or detailed diagnosis of the reason causing the disease should take place. Also, the appropriate measures of plant protection must be taken.

Below, there is a serious review of the main enemies and diseases that cause damages in oil producing industry and are described and the most common way of dealing with them is described in short.

3.10.1 Pests

3.10.1.1 Olive fruit fly (Dacus or Bactocera oleaea)

It is thought to be the most damaging pest of the oil production. The economic damage ranges between 20-50%. This pest afflicts fruits and causes early fruit falling. Due to pest infestations, edible olives quality is degraded significantly, due to a secondary infestation from the 'xerovoula' pest (*Macrophoma*). Except for quality, oil quality in olives is degraded, too, because oil oxidity increases; with the openings on the fruit skin, oil oxidation is brought about.

The pest (dipteral) is propagated in a quick pace and, according to climate conditions, gives 3-6 generations per year. It winters mainly as a nymph in the soil, as a nymph in affected fruits that are kept on the tree during winter and up to early spring or as an adult in very warm climates.

After the first female weeds appear in spring, they fly long distances and feed on honey secretions of various coccoids and from sugary fruit juices. Females reach sexual maturity and start to spawn on the olives fruits during July, when the pit gets harder. The female, after a characteristic triangular in the fruit flesh opens, fits through its ovipositor one single egg, not more. Each female can place daily up to 12 eggs and in total on average 150-200 eggs. Three-seven days later, young larvae, which are fed from the flesh and open one or two holes, are hatched. The larva completes its growth in 12-14 days and is transformed to a puparium in the fruit. The puparium completes its growth in 7-10 days and, then, new weeds come out, leaving a characteristic enclosion hole on the fruit. In this way, the first generation is completed. In a temperature over 30° C, spawning is suspended, while in a temperature over 35°C, it goes dormant. Also, spawning is inhibited when relative humidity falls below 50%. Thus,warm and dry summers cause mortality of the eggs and larvae. In these cases, dacus moves to areas of high relative humidity close to the sea and creates nes hosts. Infestation peaks happen in September and October,

when temperature is relatively high and the weather is humid. In these climate conditions, we have successive generations. The ideal conditions are: relative humidity 70-100% and temperature 24-28%.

Either chemical or biological pest management control or the combination of the two aforementioned is the treatments used against combating dacus.

The chemical battle against the olive fruit fly can be implemented either preventatively by spraying the olive grove with poisoned protein baits, preventing adult egg-spawning, or therapeutically, by killing puparіums of those pests, when close to the fruit. During poisoned protein baits, the appropriate pesticide in a dose of 0.3% of active substance with 2% attractant (hydrolyzed protein) is mixed and sprayed inside the tree canopy in the form of thick drops in a low amount of 200-300 cc. In 'therapeutic' dripping or 'cover' dripping, the whole of the canopy is sprayed with the appropriate certified pesticides.

In order to trap out pests en masse, various types of traps are implemented, which attract adults. The best results, though, have been observed by the combination of attractive food (hydrolyzed proteins ammonium salts, melasses) and pheromone, sometimes mixed with a pesticide (usually pyrethrin).

3.10.1.2 Olive moth (Prays oleae)

This moth (lepidopterus) has three generations a year; the first (antophagous) which grows in spring in closed buds, the second (carpophagus) which grows on fruits in summer and the third (phyllophagus) which grows from fall up to the end of winter. The last one is responsible for the highest damage, where infected fruits fall off and if it presents more than 10% infestation, a treatment has to be implemented. Antophagus generation is taken into consideration during low fruiting periods. In this case, when flowers open, treatment should be carried out with biological pesticides (*Bacillus thurigiensis).* Those pesticides reduce puparіums, without affecting beneficial pests (predators, hyper pests). Olive growers, not being able to predict the exact onset of adults flying, they implement spraying with various pesticides during the onset of fruit setting, aiming to prevent the puparium entrance in the fruit.

3.10.1.3 Black scale (Seissetia oleae)

It comprises the super family Coccoidea and feed on a wide variety of plants, particularly fruit plants with a preference to the olive tree and citrus plants. It mainly grows along the nerves of branches and leaves, especially underside and feeds on the sap of the plants. It causes tree depletion and defoliation,

which leads to the fruiting of next season. It excretes a sticky substance, which facilitates fungal growth. Infestations are intense in lowlands mainly, where there are densely planted olive groves with insufficient light and air and where high humidity and high temperatures prevail during summer. The pest has two generations per year. It is reproduced in a parthenogenic way, the first being during March- June and the second during September- October.

For black scale control, the implementation of garden waste is recommended, in order for the tree to have ample light and air. Additionally, sprayings with summer pulp alone or in combination with adequate pesticides are implemented during summer after egg spawning.

Except for the above enemies of olive crops, the above pests are possible to appear and cause problems in olive groves, as well.

3.10.1.4 Margaronia (Margaronia unionalis)

Adults appear in the olive groves in April- May and lay their eggs on the buds. Larvae mostly infest tender shoots in young trees and as a consequence, a side crop is created, which forms a dense canopy in those trees. The best method of controlling margaronia is spraying as soon as the weed appears.

3.10.1.5 Rynchites (*Rynchites cribripennis*)

This pest winters as a fully grown larva in the soil. It appears in April- May and feeds on the new crop and the small fruits. In July, it starts to spawn on the fruits. The larva feeds on the fruit flesh and causes fruit drop. In order to control this pest infestation, sprayings are recommended as soon as adults appear on olive trees.

3.10.1.6 Bark beetles - Phloeotribus (*Phloeotribus scarabaoides*) and Phloeofagus (*Hylesinus oleiperda*)

Adults appear in spring. They infest twigs and branches, where they dig holes and the latter dry out. In order to control its infestation, burning of the infected branches is recommended. In areas, where there is a high infestation, spraying of the olive trees, as soon as adults appear, is recommended.

3.10.2 Diseases

3.10.2.1 Peacock spots (*Cycloconium oleaginum*)

A disease that contracts mostly the leaves and causes defoliation in lowland areas with high percentages of humidity and insufficient canopy airing. In old trees, defoliation causes tree infertility.

The most apparent symptom of the disease is the appearance of circular spots in the shape of 'peacock eye' on the upper surface of the leaves. Infestation is caused by fungal spores, which are formulated on the spots of the infested leaves on the tree. Optimal temperature for the fungal growth is 15- 20 ºC, while spores need a water drop, in order to germinate. Infestations take place in spring and fall. Leaves infested in spring are an infestation source for the fall infestations.

The disease is controlled with preventive sprayings with copper fungicides. The spring spraying is implemented in spring, when vegetation growth has reached a length of 5 cm. The fall spraying is implemented during spring, prior to the first rains.

3.10.2.2 Carcinosis or tuberculosis of the olive tree (*Pseudomonas savastanoi*)

A bacterial disease of the olive tree, which causes tumors on twigs, branches and the trunk. The cultivars 'Koroneiki', 'Amphissis', and 'Megaritiki' are susceptible to the disease, whereas 'Thasitiki' and 'Kalamon' are resistant. Tumors appear small and greenish. Then, they tend to tan, crack and wrinkle.

The infestation is introduced through wounds caused by pruning, harvest by hand pole, hail and frost. The infection may appear in summer, too, when the weather is humid, through wounds created by defoliation. Bacterial transfer in small distances is carried out through rains and winds and in long distances through infected propagating material.

On order to fight against the problem, pruning during rainfalls and hand pole harvest should be avoided. Straight after frost or hail, spraying with copper fungicides should be implemented. Pruning tools should be disinfected. In summer, infected branches should be removed and burnt. When there are tumors,

they should be removed with a sharp knife and the wound should be covered with a layer of Boscalid. Also, the use of healthy propagation material, as well as spraying with copper fungicide is recommended to be carried out during summer, when the spots in fruits appear.

3.10.2.3 Olive soap (Gloeosporium olivarum)

In wet areas, part of the fruit is covered by a dark- coloured spot and it wrinkles during the maturity. Since the weather is wet, black pistils with oily pink- orange conidias appear on the spot, which are the fungal spores, appear. Conidias cover the tip and stretch up to the middle layer of the leaf, while black pistils appear in concentric zones.

The optimal conditions for the fungal growth are the wet weather with temperatures reaching 20-25 ºC. The existence of wound makes fungus entrance easier, while spores need rain drops or very high relative humidity, in order to germinate.

In areas where the disease can appear, two sprayings, mainly with copper fungicide are required, the first one during the onset of fruit ripening and the second one a moth later.

3.10.2.4 Escudete (*Camarosporium* or *Macrophoma dalmatica*)

Dry identified rotting in immature fruits (small, dark spot on the surface of the fruit, seemed to 'escudete') and soft generalized rotting in mature fruits (dehydration, shrinking). In both rottings on the fruit surface, there are black spots (fruitions, picnidios) and the cut caused by dacus.

The fungus affects only the dacus infected fruits, while it is transferred by the beneficial pest 'Prolasioptera berlesiana', which is an enemy of dacus.

Battle against dacus through preventative sprayings controls this disease, too.

3.10.2.5 Verticillium wilt (Hydromycosis) (*Verticillium albo-atrum* and *V. dahliae*)

The fungus lives in the soil as a saprophytic fungus for many years. It infects fruit plants in the root system and causes hydromycoses. It appears in soils that have been previously cultivated with cotton, tomato, potatoes, cucurbits. A lot of pests are host-fungus.

Infection takes place through the wounds of the root system during farming and provision of irrigation water. Initial symptoms include wilting - either the entire plant may wilt (apoplexy) or only parts of the plant may wilt (hemiplegy). Partially wilting plants are only partially infected. Partially wilted plants may recover at night till the fungus spreads through more of the plant. On wilting tissue, the leaves soon begin to yellow then turn brown and die. The characteristic symptoms, such as internal discoloration or streaking of the sapwood are rarely obvious in the olive tree; thus, it is necessary for samples to be checked in the lab.

There are no effective measures to combat the disease after the infection of the tree. Control is based only on preventive measures. Farmers should avoid installing the olive grove in fields where cotton, potatoes, tomato, cucurbits had been previously planted. Healthy propagation material should be used. Resistant cultivars should be planted. Surge flooding or furrow irrigation and drip irrigation should be avoided. In case of inter-cropping, the olive tree should not be combined with susceptible to the disease crops. Pruning of debilitated trees should be carried out before drying out or defoliation. Also, solar disinfection during summer may be implemented.

4 Recording and analyzing the most common cultivation techniques

4.1 SOIL CULTIVATION AND WEED CONTROL.

The olive tree is planted in a wide variety of soils and receives a variety of cultivation cares (from none to very intensive care).This results to the weeds found in Greek olive groves to vary from area to area and from olive grove to olive grove. There are differences even in the same olive grove. Generally speaking, a big number of weeds can be found in Greek olive groves and in every one and each olive grove, certain species, depending on the climate conditions and the interventions carried out in the olive grove, prevail.

Different weed species are divided depending the season they appear and are identified in the categories below:

Winter weeds germinate in the fall or early in winter, grow actively in winter and spring and dry out early in the summer.

Summer weeds germinate in the spring up to early summer, reaching the peak of their growth early in the summer and drying out in the fall.

New plants both of winter and summer weeds germinate either from spores already existing in the soil (annual weeds) or from spores and below ground perennial bodies, such as bulbs, condyles, root systems and so on (perennial weeds). Perennial weeds are much more difficult to fight, because their below ground propagation bodies are resistant during the battle against them and are able, after the destruction of their above ground part, to give new, vigorous revegetations. Perennial weeds consist of many bushy or woody species, which are very disturbing to the olive groves.

Winter weeds are not very damaging to the olive groves. They are combated prior to the onset of harvest, if they make picking from the soil difficult, and then, it is recommended they be left as a protective grass layer, especially in inclined olive groves. Towards the end of winter, a month before the onset of the new vegetation of trees, when the first summer weeds will have germinated, they can be wiped out.

Summer weeds, which germinate in dry olive groves are usually very few, unless there are spring rainfalls and enough humidity on the surface layer of the soil, therefore they may form a dense grass

layer early in the summer. Even in years of drought, though, certain deep-rooted weeds, mainly perennial (trumpet flowers, Johnson grass) or even woody (brambles, licorice root) may generate in a diverse way, as they strongly compete olive trees. Summer weeds, when they exist, are very detrimental and must be wiped out. Annual summer weeds are easily controlled in an early growth stage through a light rooting or the implementation of a post emergent contact herbicide.

Perennial summer weeds are controlled in a later stage, where a systemic herbicide must be used. Persistent woody weeds (holly, Spanish broom, etc) should be sprayed once or twice a year with the systemic herbicide during summer and be uprooted in the fall, after the first rainfalls. Re-sprayings should be implemented next summer in any revegetations, so that the olive grove can get rid of those persistent weeds.

Table 5: Certified pesticides for the olive tree vegetation

Active substance	Formula	Notes
Pre emergent herbicides		
Chlorthal-dimethyl **oxyfluorfen**	Dacthal 75 WP, Perokill 75WP Galigan 24 EC, Goal 48 SC etc.	Implementation in olive trees nurseries Implementation at least 21 days before harvest.
Pre emergent- Post emergent herbicides		
Terbuthylazine+glyphosate	Folar 34.5/18 SC	Its use is recommended for 4-year-old and over olive trees. Implementation at least 56 days after harvest.
Post emergent herbicides		
diquat	Reglone 20 SL	Its use is allowed only in oil producing olives. Implementation at least 30 days before harvest.
glufosinate	Basta 20SL, Finale 15 SL	Its use is recommended for trees which have completed 3 years since they were planted. Implementation at least 14 days before harvest.
gluphosate	Roundup 36 SL, Dominator 360 SL etc.	Its use is recommended for trees which have completed 3 years after they have been planted. In table olives, its use is allowed, only if they are harvested from the tree (not picked from the soil). Implementation at least 7 days before harvest.

The most serious problem is caused by summer weeds in irrigated olive groves, where after the first irrigation, dense vegetation from various weeds is developed (Amarantus viridis or 'vlita', lambsquarters etc.) in the wet points (basins etc). In order to control these weeds, trimming with hedge-cutters or light millings are required after their appearance. If, however, chemical control has been opted, repeated implementation of post emergent herbicides should be used. If there are any perennial weeds (nutsedge, trumpet flowers, Bermuda grass and so on), a systemic herbicide should be used. In case of drip irrigation, in order to control perennial weeds, a residual herbicide (Gol) before the first irrigation and only on the point where it is wetted, should be implemented, so as to restrict perennial weeds.

In chapter 4, a detailed account and justification of vegetation systems for the olive grove soil was carried out. In the framework of improving the quality of olive oil products, restricting soil erosion, improving its fertility through recycling its organic substance and, at the same time, restricting the use of chemical substances in an installed olive grove, it is crucial to predefine the inter cropping in a combination of leguminous vegetables and graminaceous plants during winter and incorporation of the organic substance in the soil during next spring. Green manure planting and their incorporation in the soil could be carried out through the olive grove farming in its 'aisles' in contour lines and be combined with potential added phosphoric-potassium fertilization (winter – grass lawn planting) or added nitrogen fertilization (end of winter- grass lawn incorporation)(see 4.3).

4.2 IRRIGATION

The olive tree grows flowers and bears fruits on the previous year's shoots. New spring vegetation 'dynamically' constitutes the next year's flower zone, as it is where flower primordials will grow for the next season flowering, while it contains the most productive in metabolizing activity leaves during summer of this running year.

Flower primordials do not grow essentially till the end of winter- beginning of spring. This growth is only possible when buds receive enough cold, especially in winter (many hours below 10°C for some cultivars, such as 'Konservolia', whereas 'Koroneiki' can bear fruits with less hours under cold and higher temperatures). In spring, flower primordials and flowers are formed, we have the flowering season and the initial vigorous growth of the fruit up to June. Around July- August, olive flowers do not grow significantly, while it is the period, when the pit gets harder (depending on the area and cultivar). Since mid- August onwards, the second phase of growth of the olive flesh and the oil accumulation starts. The flesh growth and oil accumulation continues until the fruit changes colour (it becomes black), where we

have maturity. All the aforementioned are very crucial stages of the annual vegetation and production cycle of the olive tree. Consequently, the potential of irrigation, as well as water availability in these stages define the olive grove's productivity.

In dry olive groves with no irrigation potential, the water ability (retaining of water) as well as the rainfall frequency, especially during the crucial stages, define the quantity of production of the olive grove. However, when there is possibility of even minimum irrigation, it is possible for the production to increase with no waste of money, if irrigated water is used wisely.

Case A. Olive grove with minimum available water

In this case, irrigation is cost effective, but if it is implemented during the year the trees will bear fruits and spring is relatively dry, then 1-2 irrigations, before and after flowering up to the beginning of June, will improve fruit setting and growth (and oil production), as well as next year's vegetation significantly.

Case B. Irrigated olive grove during a year of fruitlessness.

In this case, pruning must have been carried out during the previous winter. Initially, new vegetation 10-40 cm long is required to have been created and leaves should be in good condition in June, so that they will form a lot of flower primordiums for nest year's vegetation. Thus, water should be provided up to June. Later, during the period of summer, irrigation may be restricted, as the tree does not earn a lot. With the specific technique, the costs are reduced and water is saved.

Case C. Irrigated olive grove with satisfactory production expected

The crucial stages of this olive grove are spring up to June- beginning of July and the stage after the pit hardening from mid- August up to the satisfactory rainfalls of fall or up to the fruit ripening. Thus, if spring rainfalls do not retain enough moisture in the soil, irrigations should be carried out before flowering for better flower growth, less imperfect (sterile) flowers and better fruit setting. Residues of moisture during this period, though, help the Verticillium expansion. After fruit setting (May- June), moisture in the soil helps the rapid initial fruit growth and new vegetation. From August onwards, irrigation helps oil accumulation and the final growth of the fruit flesh. Caution is needed though, as tentative irrigations during the fall cause late ripening and softening of table black olives, favour the

growth of higher percentages of dacus populations and probably cause greater damages derived from dacus and winter frosts.

4.2.1 Irrigation methods

4.2.1.1 Surface furrow and basin irrigation

Olive groves may be irrigated with water that comes periodically through gravity, on the surface even of the inclined soils. In this case, irrigation may be carried out only through basins around the tree. Caution is needed so that the tree neck (the contact point between the trunk and the soil) is not getting wet, so that the risk from soil-derived diseases is minimized. In this case, the estimate of water quantity used is rather impossible and the irrigation frequency takes place only based on the water availability in the irrigated furrow. The efficiency of water use is low (up to 70% of the water used is available to the trees), as a quantity of water is lost during transfer, evaporation from the soil surface and transpiration from the higher, in relation to other irrigation methods, weed growing population, are intense.

4.2.1.2 Surface irrigation by individual sprinklers

This method is implemented when there is enough and relatively cheap water available. Water may enter the olive grove under pressure and the cultivar is intended for table use. 1-2 individual sprinklers are used in each tree. As individual sprinklers supply water to a larger area than in drip irrigation, water losses from evaporation and weed transpiration are higher than in drip irrigation, soil wetting in depth is lower and irrigation frequency higher than in drip irrigation, water efficiency from the olive tree reaches up to 80%. Also, the tree crown gets wet very often through this method, which makes the expansion of diseases very possible, while at the same time, the relative humidity of the olive grove is increased. This makes dacus population expand, fruits to be infected by dacus and leaves to be infected by leaf spot. Last, in case of high water conductivity, sprinklers are easily shut off and, in general, irrigation network installation and maintenance is more cost effective and takes time and the battle against weeds becomes harder (essentially only with herbicides in an ample stretch under the tree canopy), if compared to drip irrigation.

4.2.1.3 Surface drip irrigation

In this case, water comes from emitting pipes under low pressure and is implemented in one or more points per tree. Emitting pipes are installed on the soil surface or in the air, hung on trees and supported by stakes. Water is implemented in points of small soaking above-the-ground surface, surface motion is annihilated and erosion enters the soil and moves partly horizontally and, depending on soil consistency and depth, from slightly to very deep in the root zone. Water use efficiency is usually more than 90 % and it is the method that is recommended for the olive tree irrigation. Almost all the disadvantages mentioned in irrigation by individual sprinklers are not applicable in drip irrigation.

4.2.1.4 Subsurface drip irrigation

In this case, emitting pipes are under the soil surface in a depth of about 20-30 cm. Water implementation is carried out straight to the root zone, surface soil soaking is annihilated, weed growth and the cost for their control is minimized, damages of the surface pipes from birds and farming machinery are minimized, but subsurface pipes are in danger to be destroyed by rodents. Water use efficiency reaches 100% and is undoubtedly the best water implementation method for most trees, not only the olive tree. Also, it requires better quality pipes and installation along with the planting of the trees or it may be installed in a distance away from the trunk in mature olive groves.

4.2.2 Irrigation water quantity

Water quantity that has to be implemented annually is affected by the tree growth (how much space they cover in the field), the productivity of the specific year and the fruit use, rainfalls, pest control, pruning that has been carried out and, of course, the water implementation method.

The higher the vegetation cover of olive trees is, the higher the water needs are. There are sparsely planted and formulated olive groves, which cover only 20-30% of the soil surface, leaving the rest naked from olive tree vegetation. Those ones require less water than intensive olive groves, which cover 60-70% of the olive grove surface with vegetation.

During the year of high fruit setting, a great demand in irrigation water is required, in order for the fruits to grow and the leaves to function better and produce more carbohydrates for the fruits and vegetation. Similarly, when fruits are destined for table use and the size is of great importance, then water needs

are higher. Rainfalls over some mm during the cultivation period may be used by trees and, in this way, their needs in irrigation water are minimized.

Weeds growth until late in spring or green manure

They consume large water quantities in spring and consequently, more irrigation water, depending on the spring rainfalls and the soil water ability, may be required early in the cultivation period. On the other hand, the avoidance of scraping the soil helps infiltration of rain or irrigation water (in most soils) from the rainfalls, and consequently, we have decrease in the surface runoff and consequently, a bigger amount of water is stored on the soil. That means that water needs, along with the careful control of spring and summer weeds, are minimized.

Drip irrigation method is the most crucial factor, in order to save water or increase its use efficiency from the olive trees, as it was mentioned before. Last, water implementation during night or morning hours helps vaporization decrease of the water used, as well as its most effective utilization of irrigation water from the plant.

Consequently, it is difficult for someone to indicate the water quantity that must be implemented in an olive grove; however, directions towards an approach may be given. Thus, water quantities reaching 200-250 cubic metres per stremma is supposed to be a satisfying quantity for small-sized cultivars, such as ‘Koroneiki’, while the satisfying quantity for ‘Kalamon’ and ‘Konservolia’ is 300-350 cubic metres per stremma

4.3 FERTILIZATION

The fertilization required varies from area to area (soil types, rainfalls etc), even from olive grove to olive grove (cultivar, tree age, irrigation or no irrigation etc); for this reason, there are no general and typified fertilization patterns. Undoubtedly, the farmer’s aim should be to achieve the most optimal financial result with the as little as possible fertilizer administration. In order to achieve this, he/she has to start with the most official fertilization recommendations available for the specific area (preferably those based on experience over the passing of time or on fertilization experiments carried out in the area). By estimating the tree nutritional condition, in co-operation with local agronomists, he/she has to make the necessary corrections required every year, so that the required nutrient quantities both for reasons of their annual needs and the maintenance of soil fertility are provided to the trees.

In order to achieve the aim above, the olive grower will get great help from soil analysis and, more especially, leaf analysis. Soil analysis will show any possible soil problems existed. It has to be mentioned that soil analysis must be carried out at least before the olive grove installation, as it will enable the easier and more radical problem solving. If it takes place 5-6 times after planting, it helps the corrective alterations of the implemented fertilization method.

Leaf analysis is applied with success to the olive tree. Leaf sampling is carried out in winter from last year's vegetation (leaves aged 5-8 months). Those leaves are chemically analyzed, where the nutrients concentration is determined and a full picture of the nutrient condition of the leaf may be given. Other researchers propose leaf sampling to be carried out during summer (July). Leaf analysis is the only method of secure deficiencies diagnosis (even if the are existent in dormant phase).

Through the interpretation of the results of soil analysis and leaf analysis, many nutrient problems of the trees may be solved.

In the table below, a general indicative fertilization of grown olive trees is displayed, which can be used as a starting point for the areas, where no official recommendations are available.

Table 6: General indicative fertilization of the olive tree (kg/ tree)

Nutrient	Ammonium sulphate	Ammonium nitrate	Calcium ammonium nitrate	Superphosphate	Triple superphosphate	Potassium sulphate
Nitrogen (N) 1/1.5 kg	5-7.5	3-4.5	4-5.5			
Phosphate(P2O5) 0.2-0.4 kg				1-2	0.5-1	
Potassium(K2O) 1-1.5 kg)						2-3

In cases of simultaneous fertilization with potassium and magnesium, ammonium sulphate is omitted and potassium- magnesium sulphate in a dose of 3-5 kg/tree is added.

More specifically, as it was mentioned in a previous chapter, it is obvious that the olive tree's reaction to nitrogenous fertilization is spectacular. The only prerequisite is the existence of soil humidity that will enable the absorption of the nitrogen provided from the tree roots. It is clear that nitrogen fertilization

depends on the available water in the grove. Thus, in olives groves not systematically irrigated, rainfall height essentially determines quantities of nitrogenous fertilizations.

In areas with reduced rainfalls (average annual rainfall 400 mm), fertilization is recommended to be restricted (100 gr N/tree/ 100 mm rainfall height or 1Kg N/ stremma / 100 mm rainfall). On the contrary, in areas with high rainfalls, from 440 to 700 mm annually, doses of 150 gr N/tree/ 100 mm rainfall are recommended. In areas with rainfall height surpassing 700 mm, nitrogen layer should not exceed 1.5 kg N/ tree or 15 kg N/ stremma.

Nitrogen is provided in the form of manure or as one of the nitrogenous fertilizers. Manure is provided early in the fall, because it frees nitrogen to the trees in a slow pace. Inorganic chemical fertilizers are better provided in December or January, so that nitrogen is available early, in the beginning of March up to June, that is during the crucial phase of diversification and progress of flower buds to fruits. After fruit setting, nitrogen adequacy enhances vegetation, which is necessary for next year's vegetation. For dry olive groves, Nitrogenous fertilization is carried out from December to February, while for irrigated olive groves, if fertilization is carried out in one up to three doses, it gives better effects.

As for phosphate fertilization, cases of positive reaction of the olive groves to phosphate fertilization are relatively rare. This is due to the fact that trees have an extended root system that takes advantage of an ampler surface space and is able to absorb the necessary quantities of phosphate. For this reason, many researchers believe that there is always a phosphate deficiency problem for the olive tree. Thus, the recommended quantities of phosphate fertilizers are restricted only to the replacement of the annual responding phosphate quantities of the crop.

Last, in many Greek olive groves, potassium deficiency symptoms are apparent, which, if not linked to excessive drought, can be corrected through potassium fertilization. Leaf analysis may give the basis for the determination of potassium quantities, which must be added into the soil. Thus, in olive groves with potassium deficiency symptoms, leaf concentration is below 0.30% and very intense potassium fertilization is needed for the treatment of deficiency. Fertilization is recommended to be implemented during the forst year of in a ratio of 3-10 kg K_2O/ tree or 30- 100 kg/ stremma for the treatment, then maintenance fertilization should follow. In cases of olive groves with 0.30% up to 0.50% in potassium content, where we do not have deficiency symptoms, intense potassium fertilization with 2 up to 5 kg K_2O/tree or 20-50 kg K_2O/ stremma is recommended. Last, in order for leaf potassium content to be 0.50% up to 0.70%, maintenance fertilization is recommended every year with potassium quantity equal

or double than the nitrogen quantity used for nitrogen fertilization. In cases with more than 0.90%, no potassium fertilization is recommended.

4.4 PRUNING

4.4.1 Fruit pruning

For a successful fruit pruning, knowledge of the way the tree bears fruits and the pruner's experience are important. The olive tree bears fruits on last year's shoots of medium vigorousness, which are on the light-exposed peripheral zone of the tree depth (60- 80 cm). Only a few fruits are formed in this zone, close to the trunk or the branches (they only have flower buds), while weak buds give very few fruits (only a few fruit buds). Thus, fruit pruning aims to the creation of buds of medium length (15-50 cm) and to preserve the zone in good vigorousness and with ample light.

The targets mentioned above are difficult to be achieved in densely planted trees that shade each other. In this case, the fruit zone is restricted to the tree tops and some points on the north side that are exposed to the sun. When the top of these trees is cut out, in order for the tree to lower, their efficiency is decreased, as an important part of the fruit surface is removed.

In normal, productive trees, a light fruit pruning is recommended every year, where the removal of only the dense and dead branches of the fruit zone is recommended. This is because, with the passing of time, the fruit zone tends to become dense and fills up with small shoots. Following the above mentioned method of pruning, the length of shoots is improved and sufficient light is ensured in the fruit zone. This method of pruning should be stricter on trees that grow in barren and dry soils, so that the leaf surface can be restricted and foods and water can be stores for the fruiting growth. On the contrary, on trees that grow in fertile soils, or are fertilized and irrigated, pruning should not be strict, as there is abundance in food and water, both for the already existed fruiting growth, as well as for the creation of the new one. In this last case, strict pruning gives insatiable shoots that enter the fruiting season late.

Fruit pruning of table olives, if carried out properly, may improve the fruit size, by achieving the load control. For this reason, it is better recommended for thinning out of fruit branches after fruit setting to be carried out during the years of excessive fruiting.

The appropriate pruning may also minimize bearing effects. For this reason, strict pruning is recommended (with the removal of shoots of medium vigorousness that will be possibly turned into fruits) during the winter before the year of high yield of fruits. On the contrary, strict pruning that is usually carried out after harvesting during the years of high yields, makes bearing effects more intense (it exhausts the already weak from fruiting trees).

4.4.2 Renewal pruning

The olive tree has the ability to re- shoot from any point of the wood, after cutting, and this characteristic is what makes it long-living. Due to this ability of the olive tree, the renewal of old trees or restoration of old trees, that were damaged by frost or fire are possible.

Old trees of low productivity are renewed with trunk decapitation on the low part or the point of intersection (cross). It is advised for whitewashing to be carried out on trees, so as for sun burns to be avoided. For partial renewal or canopy restriction on densely planted trees that are shaded, cutting is carried out on branches or the first ramifications on proportional height. Sometimes, pruning is enough if carried out in some branches that have grown very high, so as for the trees to lower. On the point of cutting, new vigorous shoots develop, from which the most adequate ones are selected for the formation of the new structure of the tree. In all these cases, the tree enters the normal fruiting stage, after 3 to five years, depending on the conditions.

For the restoration of old trees that were infected by frost or fire, trees are left for one year, so as for the real damage to become apparent. From the new shoots, which in the meantime grow, the new branches will be formed, while all the destroyed parts are removed.

4.5 PLANT PROTECTION

In chapter 10, a short description of the main enemies and diseases that affect olive trees was carried out. From the plant protection means mentioned for the olive tree protection, the ones mentioned below are the most dangerous, as for the seriousness of the problem they create, the frequency of their appearance, as well as the restriction of residues of the plant protection formulations in the final olive products.

4.5.1 Insects

4.5.1.1 Dacus (Dacus or *Bactocera olea)*

In order to control dacus, **poisoned protein baits and en mass trapping methods should be preferred,** in contradiction to cover sprayings. The latter should only be implemented in cases, when the fruit attack is high and at least 1, even 1.5 month before the onset of harvest season.

During poisoned protein baits, the adequate herbicide in a dose of 0.3% of active substance with attractant 2% (hydrolysed protein) is mixed and sprayed in the internal part of the canopy in the form of thick drops in a small quantity of 200-300 cubic metres from the substance. In 'treatment' sprayings or 'cover' sprayings, the whole of the canopy is sprayed with the appropriate certified herbicides.

For the implementation of the en masse trapping, various types of traps are implemented, which attract adults and the best results have been provided by combinations of food attractants (hydrolyzed proteins, ammonium salts, molasses) and pheromone, often along with a pesticide (mainly pyrethrin).

4.5.1.2 Olive moth (*Prays oleae*)

In order to control this insect, **the implementation of biological substances (Baccilus thurigiensis) is recommended.** These substances minimize the puparium population, without affecting the beneficial insects (predators, hyperparasites), which during this season, propagate and are control factors of other parasites of the olive tree, mainly coccoids and, more specifically, black scale.

4.5.1.3 Black scale (Saissetia oleae)

In order to control attacks from black scale, **the implementation of waste, so as for the tree to get ample air and light, is recommended.** Additionally, sprayings take place during summer after the egg incubation with summer paste or with appropriate pesticides, when the attack is very intense.

4.5.2 Diseases

The most significant diseases, which need systematic and preventive control, especially in highly humid areas are leaf spot and olive soap. Frequent cover sprayings with **copper** substances, when environmental conditions are optimal for the attack and the atmosphere relative humidity is increased,

minimize the problems from such pathogens. Thus, at least two sprayings are recommended, one in the beginning of spring and one in the middle of fall. When conditions for the attack of plants from those pathogens are favorable, an additional spraying by the end of fall may be required.

5 Comparison of cultivation methods that Greek producers implement with the equivalent ones of the Italian producers

5.1 Installation

Installation cultivation systems implemented in Greece vary, starting from traditional olive groves (5-15 trees/ stremma), semi-intensive olive groves (8- 20 trees/ stremma) and super intense plantation olive groves (140- 250 trees/ stremma). Cultivars used for planting are of table olives ('Konservolia', 'Kalamon', 'Chalkidikis' and so on), olive oil olives ('Koroneiki', 'Mastoides', 'Lianolia', ' Kerkiras', 'Koutsourelia', 'Adramiptini' and so on) and dual purpose olives ('Megaritiki', 'Throumbolia', 'Kothreiki', 'Valanolia' etc).

The equivalent plantation systems in Italy, due to the particularity of cultivars implemented (traditional cultivars with trees of extensive growth, protected by the local community) are of low density (9 trees/ stremma) to very low density (7 trees/ stremma). There are cases, though, where plantation density reaches 12- 15 trees/ stremma. The dominant cultivars are 'Cellina of Nardo' and ; Ogliarola of Lecce' in a big percentage and then follow some imported ones in a small percentage. Those two cultivars are olive oil cultivars, are big in canopy size with big cavities on the trunk and this results the trees not to accept any cultivation techniques (such as pruning, sprayings, harvesting by hand). New plantation systems implemented are adapted to the new cultivation methods which lead to denser plantations with a smaller canopy size; this is achieved through the oil cultivars or dual purpose cultivars. Table olives are cultivated in a small percentage in Italy.

It is worth mentioning that in Greece, there are big rotations and inclinations in the relief of landscape; thus, we frequently have the use of terrace cropping, in order to avoid erosion, while in Italy there are no such big inclinations.

5.2 WEED KILLING

Weed control is an important factor, which has to be checked, in order to have increase in productivity.

Weed killing in Greece is carried out through cultivation methods (milling, bushcutters machinery) on the one hand and on the other, with the use of contact weed killers (if we deal with annual weeds) or Inter- Systemic systems (if we deal with perennial weeds).

In the framework of improvement of the olive oil products quality, we should first implement the cultivation methods and only if it is of great necessity to move on to chemical formulations.

Also, it would be positive if we chose an intercropping mixture of leguminous vegetables and graminaceous plants during winter, so that the organic mass be incorporated in the soil next spring. Through this technique, soil fertility is increased, erosion is restricted, the olive oil products quality is improved and the use of chemical formulations is restricted.

In Italy, because of the fact that the biggest percentage of trees is intended for oil production and is of great growth, weed killing is accompanied with collection nets, which hinder weed growth.

5.3 IRRIGATION

The most significant stages during the production period of the olive that have to be taken into consideration, if there is possibility of irrigation, are two. The first one is the formation of flower buds, in spring, and the initial appearance of the fruits, up to the end of June. The second stage is the growth of the olive flesh and the olive oil accumulation and lasts from mid- August up to the sufficient rainfalls in autumn. During these two crucial stage of the annual vegetation and productive cycle of the olive tree, irrigation takes place as long as production is likely to increase. Irrigation methods, as implemented in Greece (see 4.2.1) are as follows:

- Surface irrigation through furrows and basins (mostly implemented on sloping soils)
- Surface irrigation through individual sprinklers (when there is enough water available)
- Surface drip irrigation (optimal method for the olive tree)
- Subsurface drip irrigation (optimal method for the olive tree)

The water quantity provided to the trees is a component to many factors and these are:

- Vegetation cover of the field with olive trees
- High fruit setting year
- The olive use (table, olive oil olive, dual purpose olive)

- Weed growth or non growth
- Pruning strictness
- Water implementation method

Water quantities considered satisfactory reach 200-250 cubic metres per stremma in the case of small fruit cultivars, and 300- 350 cubic metres per stremma for the table olives.

In Italy, most part of land is not irrigated; consequently, cultivars which are used are water- resistant.

5.4 FERTILIZATION

Soil composition is an important factor affecting the fertilization of the olive trees. Also, rainfall intensity and frequency is another factor, which has to be taken into consideration during fertilization.

In Italy, and more specifically in the area of Salento, we have a high calcium content, as well as sand and clay deposition. In the area of Lecce, we have rocky soils containing calcium. Rains in the neighbour country are scarce, unstable and fall mainly during autumn- winter.

In the Greek land, we have a variety of soil consistencies and climate conditions. For this reason, there are no specific methods of fertilization. There is only the target of the olive producer, which is the achievement of the optimal result through the implementation of as low as possible fertilization.

The ideal method for the achievement of the producer's main target is the soil analysis, through which any shortages of the soil in nutrients become obvious, and more specifically leaf analysis, which constitutes the unique method of secure deficiency tracing (even if they exist in a dormant stage).

In Greece, before the installation of an olive tree, soil analysis is implemented in some cases, which is repeated for any fertilization corrections every 5 to 6 years. As trees grow, leaf analysis is also implemented in the way mentioned above (see 4.3) for a stricter control of nutrients that have been absorbed from the plant. After each analysis, agronomists recommend a fertilization program, depending on each case independently.

5.5 PRUNING

5.5.1 Fruit pruning

The aim of fruit pruning is the creation of medium sized fruit buds (15-50 cm) and the conservation of fruit zone in good vigorousness and ample lightning.

In olive oil producing areas of Greece, normally producing trees go through fruit pruning once a year by removing only the dense and dead branches from the fruit zone. This is due to the fact that the fruit zone tends to become denser and full of small buds. In this way, satisfying levels of lightning are achieved and the length of buds is improved. In arid and dry areas, stricter fruit pruning is applied, so as to moderate the leaf surface for water and nutrients saving.

In cases of table olive cultivation during the years of excessive fruiting, thinning of the branches is carried out slightly after fruit setting.

For the phenomenon of bearing effects, strict pruning is carried out (removal of buds of medium vigorousness that possibly will develop into fruit buds), during the winter before the year of high fruit setting.

In Italy, pruning takes place every two years during harvesting, while it is supplemented with the removal of the insatiable and young buds.

5.5.2 Renewal pruning

Old and non-productive trees are renewed with strict pruning of branches (decapitation) in the area of the trunk (cross). In densely planted trees, which are shaded for partial renewal or restriction of the canopy, pruning takes place on branches or the first crossings in equivalent height. In cases of frost, pruning takes place during the next cultivation period after the frost, so as for the real size of damage to be obvious. All damaged parts of the tree are removed. In both countries, Greece and Italy, the same pruning way, concerning renewal pruning, takes place.

5.6 PLANT PROTECTION

5.6.1 Olive fruit fly

In order to control the olive fruit fly in Greece, poisoned protein baits, as well as en masse trapping, are implemented. Cover sprayings are implemented only in cases, where the fruit damage is high and at

least 1 to 1.5 month before harvesting. There are cases, though, that cover sprayings take place without the implementation of the necessary population control.

In Italy, cover sprayings are implemented, but they are avoided in some cases, so as the oil produced is free of fertilizers residues.

5.6.2 Prays of the olive

In both countries, its control takes place through the use of chemical formulations and only in some rare cases of organic farming, chemical formulations are used (Baccilus thurigiensis).

5.6.3 Black scale

Its control is achieved through garden waste, so that the tree canopy receives ample light and air. Additionally, sprayings with summer pulp alone or in combination with other adequate fertilizers are implemented during summer after egg hatching.

5.6.4 Diseases

Peacock spots and olive soap constitute the most serious diseases of the olive tree and they are controlled through systemic and preventive interventions, especially in areas with increases levels of humidity. Frequent cover sprayings with copper formulations, when the environment temperatures and atmosphere relative humidity favour the spread of the disease.

5.7 HARVESTING

In Italy, due to the fact that olive trees in their majority are olive oil trees and their dimensions are vast, harvesting takes place with special rakes, portable vibrators or larger sized vibrators in special harvesting nets. Then, the removal of waste (leaves, branches etc) and their transfer to the local mills follow. There are cases that harvesting takes place by hands.

The harvest period starts from mid- November (early) up to the end of December (late).

In Greece, olive harvesting mainly depends on its origin. In the cases of table olives, harvesting is implemented by hand (one by one) and in a few cases, with special rakes. In the cases where we have

harvesting for oil production, it is then carried out with rakes or with vibrators or in the special harvest nets. In quite a few areas of the country, pole beating is implemented. Through this method, labourers beat the branches, when fruits reach the adequate ripeness stage and fall easily. Next, the removal of waste (leaves, branches etc) and their direct transfer to the local mills follow. In other areas, for cultivars the fruits of which do not fall easily through beating ('Chondrolia Critis'), the fruit is left to fully ripen and fall naturally on the soil, where it is collected from.

Most table olives are harvested in our country from end- September up to mid- November, depending on the cultivar and the climate conditions prevailing in the area. Green olives are harvested from the end of September up to beginning of October, when the fruits are immature, but have taken their definite shape. Black edible olives are harvested a little bit later than November- December, when the fruit has blackened, but before it has started to soften.

Olive oil olives are harvested very early. The most suitable period is when the fruit has obtained the larger size and the formation of oil has been formed. This stage depends on the cultivar, the climate conditions and the cultivation care implemented.

6 RECORDING OF CRITERIA OF RESEARCH AREA SELECTION IN DISTRICT LEVEL (LOCAL COMMUNITY)

Olive cultivation is of significant importance for the prefecture of Epirus. In some areas, there is the tradition of 3 centuries in cultivating olives. Many of those olive groves are still preserved and are of historic and ornamental value. In our days, in a land of 304,000 stremmas, almost 2,000,000 trees of oil extracting cultivars are cultivated, mainly in the regions of Thesprotia and Preveza. Also, 1,250,000 trees of edible olives cultivars, mainly in the region of Arta, are cultivated, too. (Operational Scheme 'Basket of agricultural products of the prefecture of Epirus').

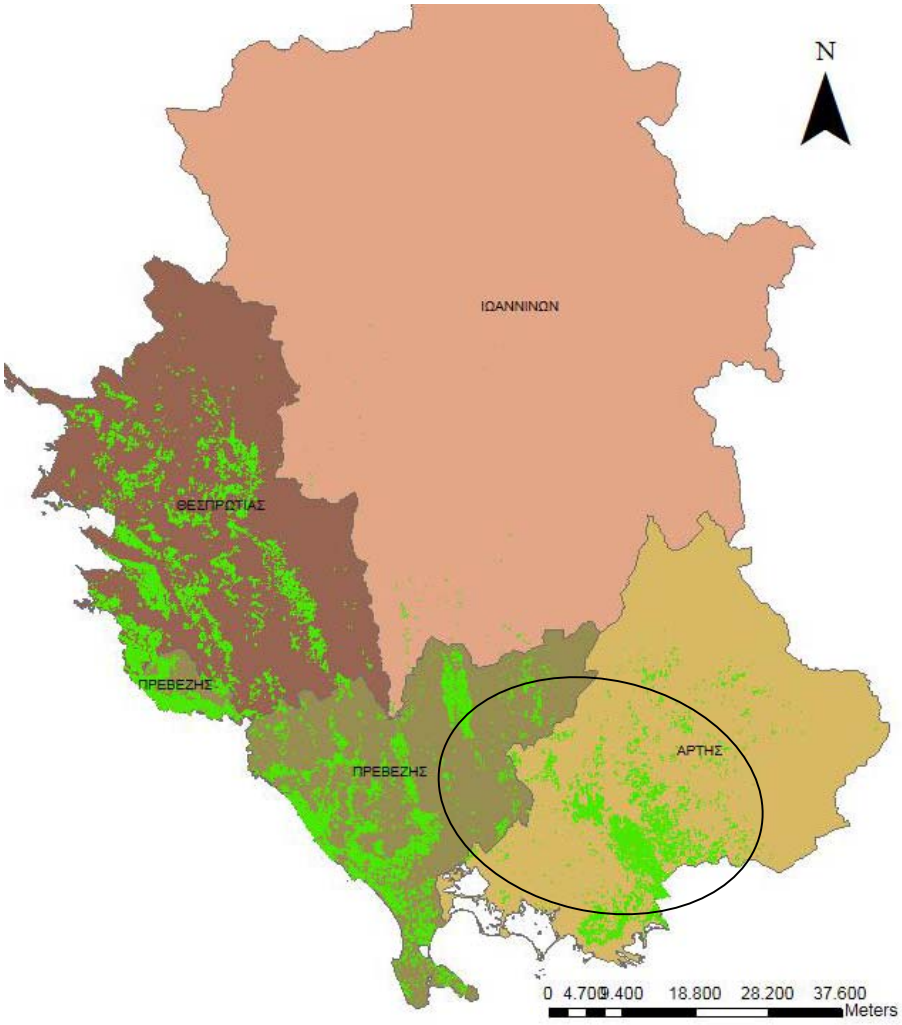


Figure 1: Map of cultivation of olive trees in Epirus (Source: map provisioning Agroquality). The area that was used as the object of research has been circled.

In the areas of Thesprotia and Preveza, 'Lianolia Kerkiras' is the prevailing cultivar and then follows 'Koroneiki', as well as the local cultivar of Thesprotia, 'Nisiotiki'. Fruit pressing is carried out in 46 mills. There are 5 particular oil standardization companies, which however, standardize a very small quantity of the product produced. Except for the oil extracting olives, a big quantity of table olives of the 'Konservolia (Chondrolia) Artas' cultivar is used for pressing, too.

Edible olive production is very significant in the region of Arta, where in 50,000 stremmas, the recognized cultivar of 'Konservolia Artas' (PGI) is cultivated. 75% of the land mentioned above (37,707 stremmas) are active olive groves. 70% of the groves is situated in hilly, semi- mountainous areas (Pantanassa, Ammotopos, Grammenitsa, Grimbovo, Vlaherna, Peta, Megarhi, Fotino, Sellades and Dimario). 15% of the areas are close to the banks of the Arachthos River (Neohori, Kommeno, Loutrotopos, Sikies, Peranthi), while the remaining 15% is situated on the mountainous areas of Arta. In the region of Preveza, and more specifically, in the former boroughs of Thesprotiko and Louros, around 21,100 stremmas of edible olive are cultivated. In the Prefecture of Ioannina, the olive is cultivated actively in a small area of 2,500 stremmas.

The research was restricted only in the nearby regions of Preveza and Arta, where olives are cultivated, due to the easier accessibility. Ioannina was not included in the research, due to the small number of olive groves existing in the area. The Prefecture of Thesprotia was not included either, for practical reasons, such as distance, a factor that would need more money than expected for the survey to be carried out.

Initially, an effort for the survey to be carried out by covering the whole districts of the semi-mountainous areas of the Prefecture of Arta, such as Vlaherna, Grammenitsa, Peta was made, in order to have a complete representative picture of some districts, where the cultivation of olive groves is the prevailing one. This speculation, though, met with the obstacle that there were a lot of oil producing cooperatives in those areas; thus, the debates among them were not a few and this would result to unreliable data of the final results of the survey.

In order to deal with the problem arisen, it was decided, after a meeting between the team members and the scientific director of the project, to restrict the field research into one district, along with the data taken by one common cooperative of oil producers of this area. Next, this data was to be compared with the data taken by the wider areas of the prefectures of Arta and Preveza.

With the aim to assure co-operation among the oil producers and reliability as for the data, the team members decided to turn to producers they know in the circles of their own social and friend

environment. Consequently, the district chosen for the wider area of Arta was Megarhi. Based on the same criteria, as well as for practical reasons, the survey was restricted in nearby areas, which are characterized as olive oil producing, in the region of Preveza, such as the municipal community of Thesprotiko, belonging to the municipality of Preveza.

7 MAKE OLIVE PRODUCERS OF THE SELECTED LOCAL COMMUNITY LIST

For the selection of the olive producers who were eager to co-operate to the survey, the factors which were taken into consideration for the municipal district of Megarhi were

- the IACS declaration form of year 2012
- their participation to the local cooperative
- their main occupation being farming

For the wider area of the prefectures of Arta and Preveza, the occupation with olive cultivation exclusively was a basic criterion for the co-operation in the framework of the program. The participation in cooperative groups, the exclusive occupation with the olive cultivation, the cultivated cultivar and the olive grove direction, the age of the trees, the possibility of irrigation of the trees were not a crucial factor into selecting a producer willing to cooperate.

The team members made contact with the producers and after giving them the information needed in relation to the program targets, they listed the producers that were willing to participate and cooperate. In Appendix 1, the list including the producers' details is mentioned. Fifty producers from the municipal district of Megarhi that participate in a local cooperative of olive producers that deal with the cultivation of the olive exclusively, as well as 30 producers from the wider area of the prefectures of Arta and Preveza were listed.

8 Creation of questionnaire for growers

In the framework of the program "AGROQuality, for the development of a functional system of continuous control of the quality and traceability in the food chain of the primary sector in Greece and Italy, the survey was focused upon the olive and its products cultivation.

The main targets of the survey, within the framework of the development of a model of overall management, were:

- The listing of the parameters of the olive cultivation
- The creation of a series of guidelines referring to the optimal methods of olive cultivation and the product promotion- trading.
- The enhancing of product competitiveness through documentation of their quality characteristics.

For this target, the collection of data concerning the area's olive producers, the olive exploitation, the implemented cultivation method and the trading of the product obtained considered very crucial.

The collection of data was based on:

- Questionnaire introduction
- Personal contacts and interviews

After the team members meeting, it was decided the questionnaires to include data concerning:

- The olive producers profile
- Their familiarization with the PC use and Information Technologies
- Their interest concerning the quality control and traceability of the product obtained.
- Data concerning the olive exploitation
- The implemented cultivation methods
- The economic result of the expoitation
- The olive producers' suggestions as for the quantity and quality improvement of their product
- Their interest in their further co-operation within the framework of the program.

For practical reasons, the questionnaire was structured in two sections: The first part was about the olive producers' personal details and their stances concerning their olive exploitation, while the second referred to the implemented cultivation method and the producers' interest to co-operate in the framework of the program.

Initially, a text in the form of a letter mentioning the reasons and the targets of the survey was written. This text was decided to be given to each producer during the first meeting with the team members, so that the producers make sure of the target of the survey in writing too. This technique was considered to help the producers stop being insecure and cautious for participating and co-operating in the framework of the program, so that the data asked will be recorded with as much accuracy as possible.

Based on the guidelines for the creation of the questionnaires, the project team members dealt with the recording data that had to be received, the creation of the adequate questions for the collection of data and the creation of the questionnaire. (Appendix II)

For the creation of the questionnaire, three types of questions were used:

- Closed questions or questions with specific answers,
- Open questions and
- Questions with answers in a graduated scale.

Questionnaires were created in the languages of both countries participating and were completed after personal interviews with the producers.

9 On spot research with the creation of questionnaires after personal interviews with the olive growers

Interviews were received by the agronomists of the research team. Before the conducting of the interviews, the necessary guidelines were given by the scientific director of the program as for the way the producers should be approached, as well as the importance of recording of their answers.

During the first contact of the interviewer and the olive producer, the informative letter concerning the survey and the intended interview was given to the interviewee. Also, all the necessary data concerning the target of the survey were given and the appointment for the interview to be carried out was made. At the beginning of the interview, it was clarified that the questionnaire was not a test, that there was no right or wrong answer and that only statistic data would be attributed. In each section of the questionnaire, a short introductory description was preceded related to the content that would follow. The transfer from one to the next section was accompanied with introductory notes, which facilitated the transfer and maintained the flow of the questions smooth. During the interview, no other persons were present, so as not to affect the result of the answers. For this reason, the interviews were most commonly carried out at the interviewee's house. All the questions followed the same pre-determined order, were read as they appeared in the questionnaire and the answers were registered at the time of them being expressed. By the end of the interview, the interviewee checked the questionnaire in case there were any mistakes or any supplementary notes should be added.

The personal contact with the interviewer is offered for direct clarifications of the questions, the aim of the survey and the importance of the interviewee's participation. Thus, there were a few interviews that were carried out through the telephone (for example, in case some persons were not around the area). This method had the same structural characteristics as in the face-to-face interview, the questions were asked in the sane way following the same order, by giving any clarifications if needed. In order to determine the place and day of the interview, the interviewer would made the arrangements himself/ herself.

It has to be mentioned that the costs of the personal work were estimated according to the costs a labourer would take, in case he/ she was hired. The price of the costs in this case would be recorded after a specific question the olive producer would ask during the interview.

During the interviews, it was found that a quantity of the produced olive oil was intended for the same consumption. This quantity was registered and was estimated to the income of the exploitation in the price the producer mentioned.

10 Questionnaire data entry in a form

After the completion of all the interviews, the completed questionnaires were numbered in ascending order. Next, the answers were codified (Appendix III) and the data was introduced in a digital form in an EXCEL archive, so that their statistic analysis (Appendix IV, codified answers), processing and conclusion extracting in the form of charts and diagrams could be possible. All the data had to be transformed into a numerical form, which was important for the data analysis.

1. In the single answer questions, the answers were registered with the equivalent codes, which appear in the last column, for example 1 or 2 or 3 etc.
2. In the questions referring to the producers' age, the age of the trees and more generally to numeric variables, the number registered, i.e. the answer that most producers gave was for example 45 or 120 etc.
3. In certain questions, where variables are of a numeric form, data categorization was performed. Each category was registered with the equivalent codes mentioned in the last column.
4. In the multiple answer questions, the answers were registered, the combinations were traced and registered with the equivalent codes mentioned in the last column.
5. In a few questions, as in the case of fertilization, a data modification took place, for example the calculation of the administered fertilizing units in a nutrient based on the fertilization action implemented and number registering, which appeared on a column. Where necessary, a new data grouping in categories was created, each category being registered with the equivalent codes mentioned in a separate column.
6. Open question answers were registered in the form of a text.

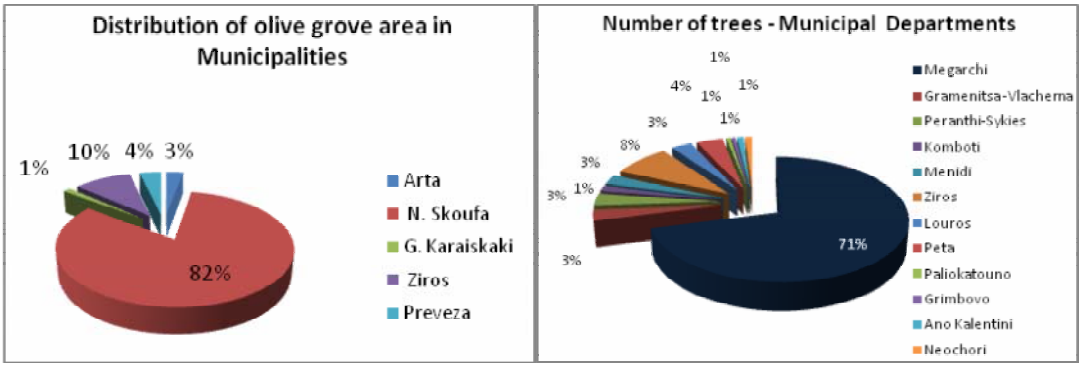
11 Statistical analysis of the research results

11.1 SECOND PART: REGARDING LAND PARCELS AND CULTIVATION TECHNIQUES

For the statistical analysis regarding the second part of the questionnaires, the statistical program SPSS version 8 was used. For the data analysis regarding the agricultural parcels and the cultivation technique implemented, frequency charts were used. Where necessary, the average of the prices and their typical deviations were estimated. For the evaluation of the yields of the cultivated cultivars, the production costs, the income per stremma compared to the plantation density, a simple dispersion analysis (One Way Anova) was used. As for the average separation, the statistic criterion Dunkan was used. For the visualization of the results (charts), Excel (Microsoft Office 2007) was used.

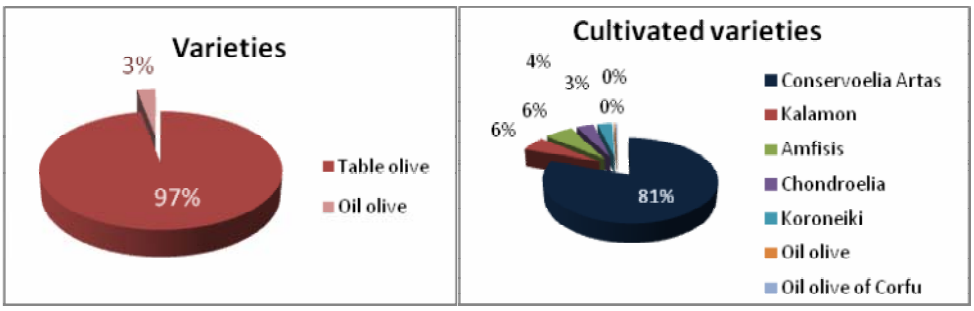
11.1.1 Land particles with olive trees

From the data analysis regarding the second part of the questionnaire, it was noted that 80 olive producers (the ones constituting the sample) cultivate 278 parcels, 32,484 trees in a land of 1,816 stremmas. The registered olive groves are divided into 5 different boroughs. The largest part of the olive groves (82%) belong to the borough N. Skoufas and, more specifically, to the municipal district of Megarhi, where the largest percentage of the sample of trees (72%) is allocated for reasons mentioned above.

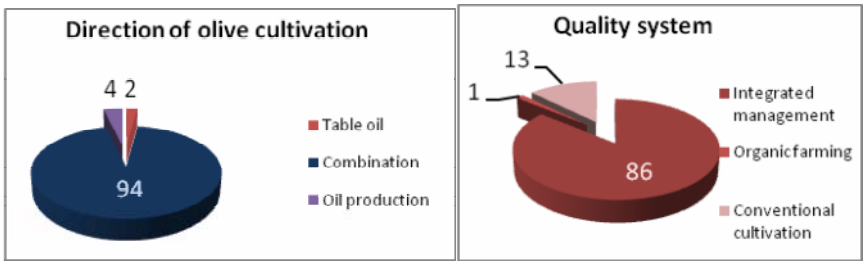


In the sampling area, mostly edible olive cultivars are cultivated (97%), from which the geographically recognized (PGI) cultivar, known as 'Konservolia Artas' is the main cultivated cultivar of the sample

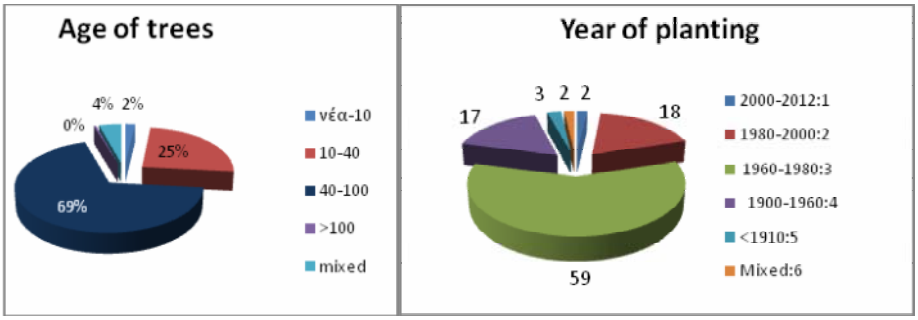
(81%). In a small percentage, the 'Kalamon' (6%), 'Amfisis' (6%) and 'Chondrolia' of no specific cultivar (3%) are cultivated. From the olive oil olives, the 'Koroneiki' cultivar (3%) is cultivated, while in two olive groves in the area of Oropos, 'Lianolia Kerkiras' is cultivated.



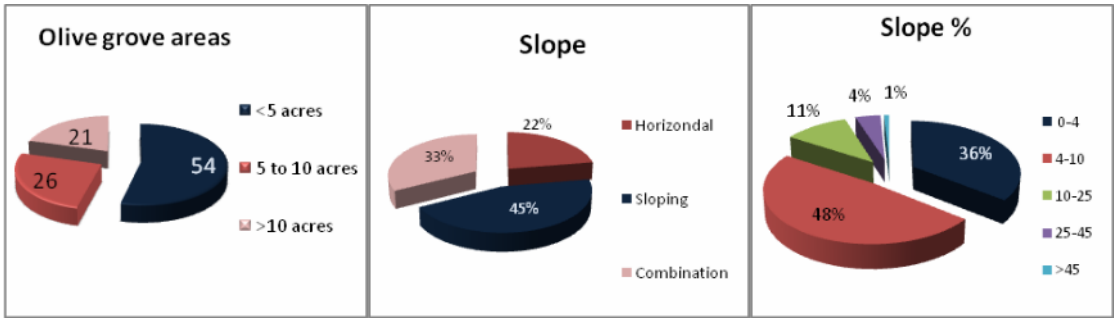
The edible cultivars are cultivated, in order to produce table olives. Small-sized fruits or fruits of a low commercial value are used for oil production. Directed olive groves, cultivated for olive oil production only or edible olives are of a small percentage only (4% and 2% respectively).



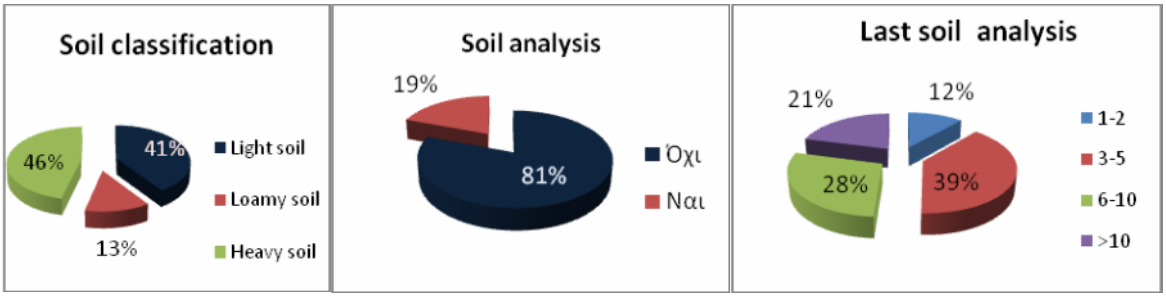
Most olive groves (90%) were adapted to the 'Complete Management' system. Its application is environment- friendly and leads to high quality products, which through the adequate promoting, can ensure better prices to the international and national market. In a very small percentage of 1%, organic cultivation is implemented, while 9% of the olive producing exploitations apply conventional cultivations.



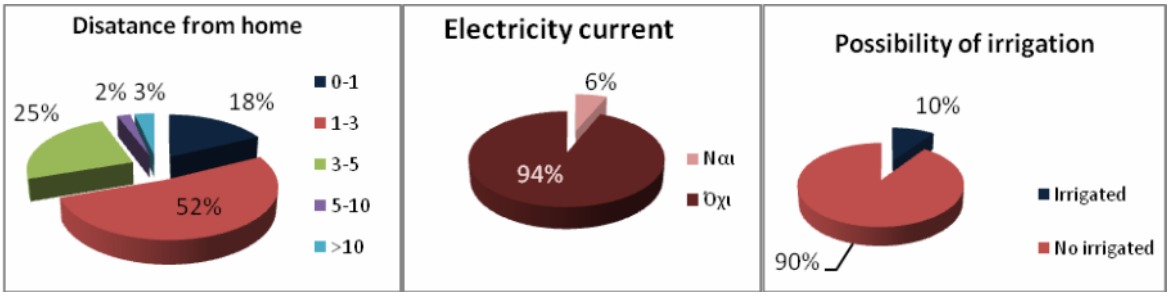
Most olive groves (50%) were installed between 1960 and 1980. 25% of the trees are 10-40 years old, most of them (69%) being 40-100 years old, while young olive groves constitute only 2% of the sample.



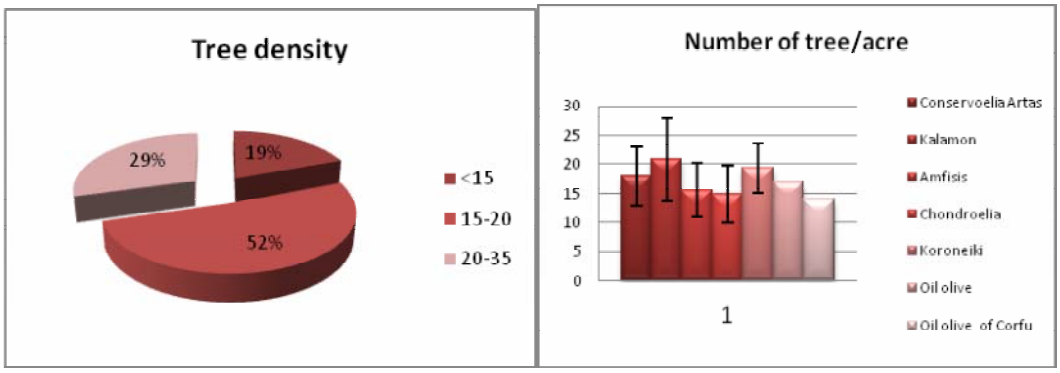
The producers possess 22.5 stremmas of olive groves on average, which are composed of 3-4 agricultural parcels on average. The fragmentation of the agricultural parcels and their small size are negatively related with the product competitiveness. Most olive groves are small in extent in stremmas, sloped with medium slopes. About half of the olive groves (54%) of the sample are smaller than 5 stremmas in extent, 26% being from 5 to 10 stremmas and 21% more than 10 stremmas. 78% of the olive groves are of a sloped soil or combine a sloped and horizontal soil. Around half of them (48%) are of medium slopes from 4 to 10%, 36% are of smoother slopes, while on olive groves with a steep slope, the construction of terraces for the soil protection from erosion is necessary.



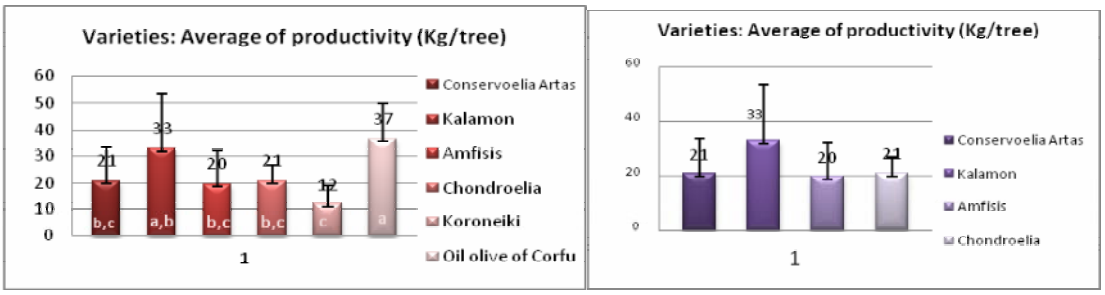
Soil analysis which is a tool that helps towards the production costs reduction, through the implementation of the necessary nutrients only, as well as the excessive fertilization, has only been implemented by a small percentage of olive producers (19%). Half of those producers have applied soil analysis within the last five years. Soil analysis has not been implemented to 81% of the olive groves. The answers to the question regarding the soil type have been given either based on the soil analysis results or on empirical criteria. Thus, as for the mechanical composition, 46% of the olive groves are characterized as deep, clay soils, 41% as slightly sandy and 13% as of medium composition.



Only 18% of the olive groves are close the producers' home (<1 km). Most of them (52%) are 1-3 km far and 5% are even further than 5 km. There is no electricity in the majority of the olive groves (94%) and irrigation potential (90%).



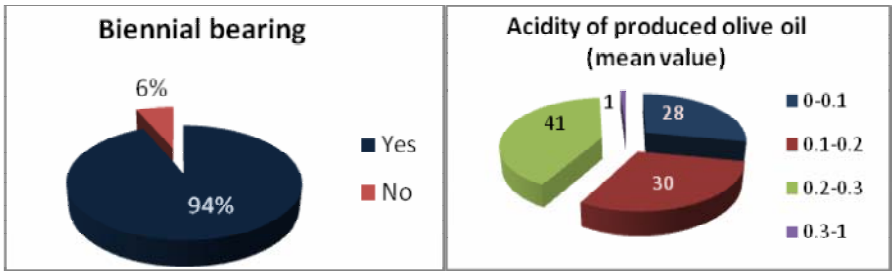
The intensive plantation system with density higher than 20 trees/ stremma has been applied to 38% of the olive groves. About half of the olive groves (52%) are planted through an intensive plantation system (15 to 20 trees), while in traditional olive groves, density plantation is lower than 15 trees/stremma. The cultivated cultivar and the direction of cultivation are, amonst others, factors that affect the plantation density. The plantation density average of the below cultivars is: 'Konservolia Artas'= 18 ± 5, 'Kalamon' = 21 ±7, 'Amfisis'= 15.6 ± 4.5, 'Chondrolia' = 14.9 ± 4.8, 'Koroneiki' = 19.4 ± 4.3 trees/stremma.



Through the data statistics analysis regarding the average production/ tree (Kg) for the cultivated cultivars in the area studied, it was found that:

Cultivars cultivated under dry conditions vary statistically in a significant degree as to the average production/ tree in significance level 5% (Anova p = 0.02). Higher yields were observed in 'Ladolia of Corfu' and lower yields in 'Koroneiki' (Dunkan). It is highlighted that 'Koroneiki' has not yet reached its fully productive age and 'Ladolia of Corfu' concern only two olive groves. New statistics analysis of the edible olives yields has indicated that no significant difference is observed between them regarding the average yields/ tree. A higher average yield was observed for 'Kalamon' (33 ± 20.1 Kg).

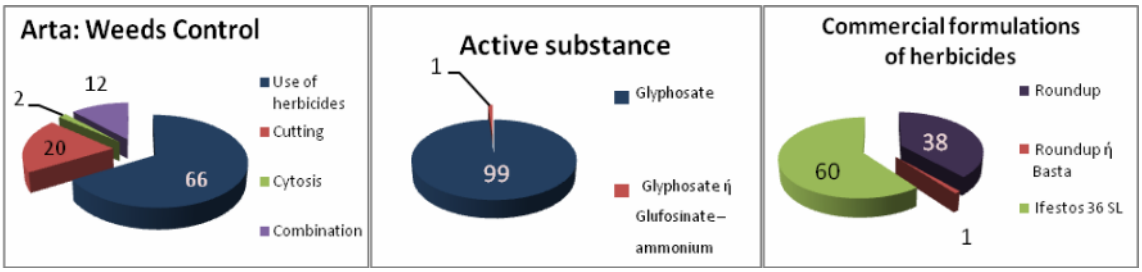
The above average yields / tree were estimated based on the average annual production. It has to be emphasized that in 94% of the olive groves, trees go through biennial bearings. Biennial bearings concerns only the phenomenon of increase and decrease of the olive tree yields, from year to year. According to relevant surveys, during the high yield year, the olive tree appears large decrease in nitrogen, potassium and phosphor levels with a simultaneous increase in calcium content. All these changes result in the weakness on behalf of the tree to give satisfactory yields next year. The biennial bearing effects restriction is based on cultivation preventive actions, such as pruning and fertilization.



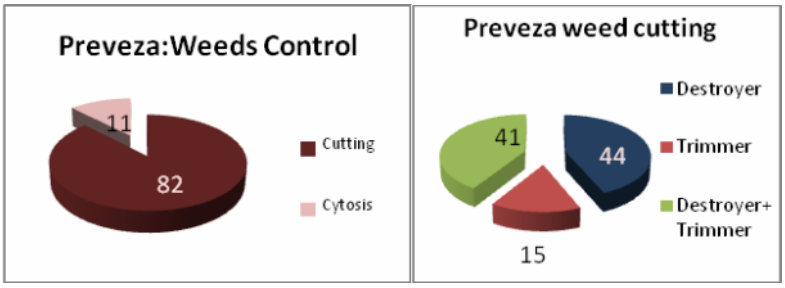
The producers' average annual oil production was 0.775 tn. The oil produced is of high quality and acidity ranges for the total of the production (99%) between 0 and 0.3 and is characterized as extra virgin olive oil.

11.1.2 Weed killing

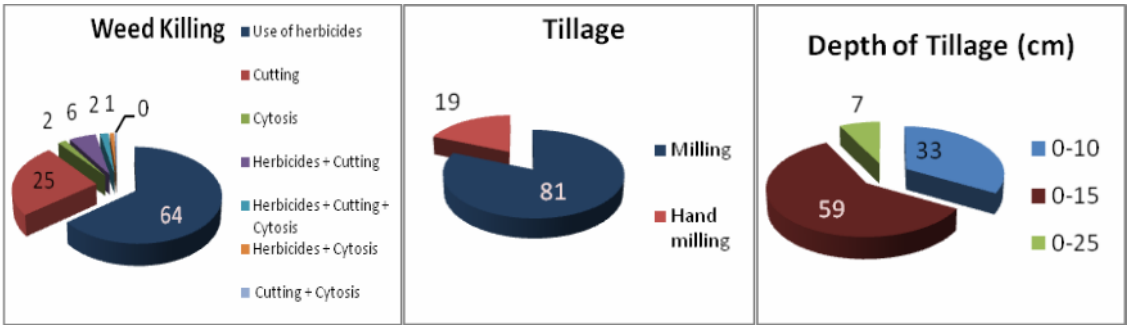
Through data analysis, it was found that different techniques are applied by the producers for the weed control in the olive groves of the prefectures of Arta and Preveza.



In Arta, producers use by majority (66%) the non-farming technique of the soil with simultaneous use of herbicides. Through non-farming, the surface root system of the olive tree is not damaged, the soil structure is not disrupted and erosion is avoided. When using herbicides, specific substances must be used for the olive tree cutivation in such a way that the produced olive fruits are not damaged. The drastic formulation Glyphosate is used almost with no exception (99%), in order to chemically control weeds through formulations under the namings Roundup (38%) or Ifestos (60%).Gluphosate is an inter systemic non- selective leaf herbicide. It radically combats broad-leaved, grassed, annual and perrenial weeds. During its use, the label instructions must be followed, so as to avoid any danger of toxicity. During its application, nozzles producing medium-thick or thich droplets of spray must be used. Also, thin droplets should be avoided, as they stay longer in the air, are light and are carried away by the air in long distances. Except for Glyphosate, there are other olive trees weed control herbicides. The weed species of the olive grove should be examined and the adequate weed killer be applied.



In the areas of Preveza, weeds are usually killed through the cutting technique throught the use of destroyers (44%), trimmers (15%) or the combination of both (41%). Weeds are cut before they flower, so as not to compete olive trees in water and nutrients, remain on the surface of the soil and create a protective layer that helps the maintenance of the soil humidity.



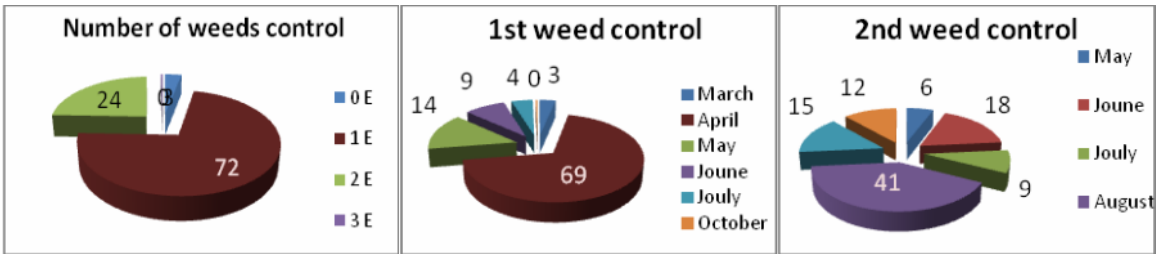
Soil cultivation is achieved in 5% of the sample olive groves through the use of milling (81%) or hand milling (19%) and aims to control weeds, to improve permeability, to ensure better ventilation in the soil and the manure integration, in case of organic fertilzation. In a percentage of 59%, depth processing reaches 0-15 cm, in 33% of the olive groves 0-10 cm and in small percentage 0-25 cm.

The continuous soil processing may have negative effects, such as the creation of wounds on the surface of the olive tree roots, which favours the soil pathogenics attack (Verticillium), the compression od the deeper soil levels during soil erosion in sloping olive groves, where the phenomenon of surface runoff is intense. In general, soil mechanical processing must be restricted as much as possible and only be carried out when its aimplementation is necessary.

When surface processing and annual weeds wiping out take place, it is advisable to avoid the use of rotary milling machines and prefer a milder brusher or gearing harrows. Also, the exclusive use of miller in olive groves with perrenial weeds and, alternatively, ploughing should be implemented. For the common processing, plows should be used.

However, in areas, such as the one studied in this survey, with a high percentage of rainfalls during winter, artificial soil plant covering by seeding the adequate plant species (graminaceous, leguminous or a mixture of both) depending the target of the green manure (composting, mineralization) or the formation of a natural green lawn by self- seeded plants and their integration or cutting and surface covering at the end winter.

The soil processing depth in spring, since it is necessary to be carried out, should not exceed 10 cm in depth.

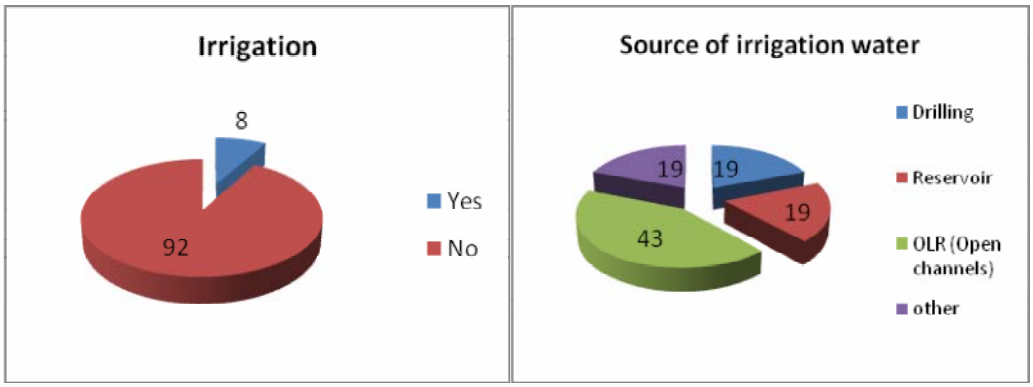


In the largest part of the olive groves (72%), a weeds control operation is implemented in April (69%). The target is to combat weeds four up to six weeks before the onset of the summer tree growth. Certain producers delay weeds control in spring up to early summer (27%), in order to control both summer and

winter weeds at the same time, reduce the operations number and consequently, the cultivation costs. However, this technique indirectly damages especially dry farming,as weeds are especially compatible. A second operation is implemented from 24% of the producers, most commonly in August (41%).

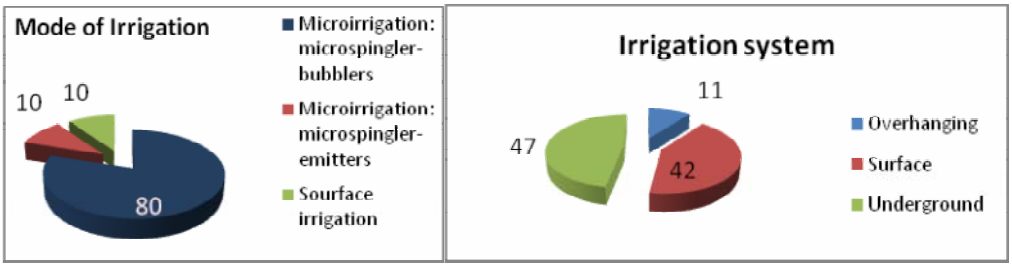
11.1.3 Irrigation

The olive tree is a water- resistant tree. Due to a high percentage of rainfalls in the area, it grows mainly as a dry cultivation. Only 8% of the olive groves constituting the sample are irrigated. Due to the small number of the sample (irrigated olive groves). The survey results may not represent the picture of the irrigated olive groves accurately. Irrigated water mainly comes from OLR (Organization of Land Reclamation) (43%). In some areas that are around the area of Grammenitsa, resrvoirs have been constructed on hills (19%), which save the winter rainwater. Water moves from the reservoirs to the olive groves through a natural flow and is used towards their irrigation during summer months. 19% of the irrigated olive groves takes water from drillings. Water pumping from drillings should be controlled, so that there will not be a great demotion to the underground water table or displacement of the brackish zone in case of the existence of coastasl areas, something that will damage drilling and also may increase soil salinity. 19% of the producers use other water sources, such as irrigation networks, water tranfer through tankers, water pumping from the river.



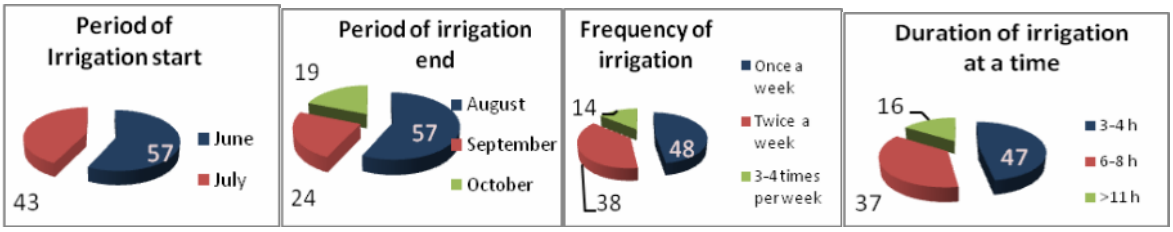
Water implementation should be carried out in such a way that there are as less water and nutrients losses as possible due to deep percolation and surface runoff. In order to decide the irrigation technique, soil inclination (excluding drip irrigation), the available water quantity, effectiveness and

installation costs of each technique should be taken into consideration. In most irrigated olive groves, a sub surface irrigation network has been installed (47%), while the percentage of the surface network (42%) is of significant importance, too. In 80% of the olive groves, microsprinklers (nozzles) are used and on spot irrigation is used in a small percentage only (10%), Last, in some cases, natural water flow is used. Natural flow is not a recommended system, due to the large water consumption, the nutrients and the uneven watering washout.



In order to define water need of the olive grove, the area climatic data, the soil mechanical composition, as well as its natural properties, such as the porous soil, water abilities and olive groves characteristics, such as age and root system depth should be taken into consideration.

In 57% of the olive groves, irrigation is implemented during summer months starting in June up to the end of August. In 43% of the olive groves, the onset of irrigation is carried out only in July while in 43% of them the end of irrigations is carried out in the first months of fall (September – October).



Large olive trees demands in water are concentrated during specific periods of the year, such as in March – April, when flower buds differentiation takes place or in May – June, when fruits flower and set or in July, when the pit is hardened. Also, the period from the beginning of August up to the end of

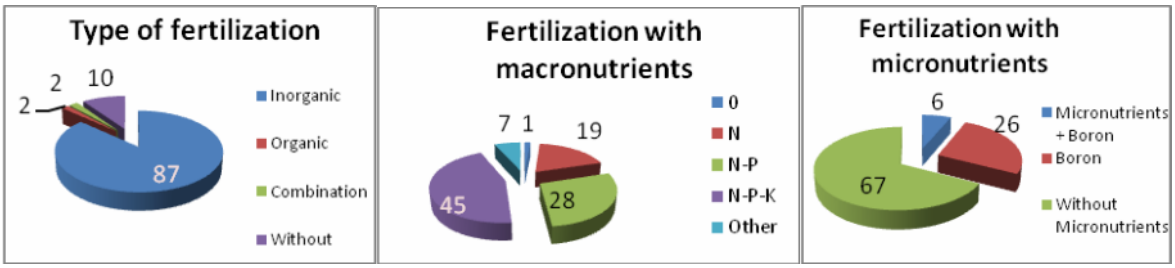
September, when the fruit gets soft and the oil is formed is very crucial, too. In fall, if the tree has quite a large quantiy available, buds grow enough, investing in such a way towards a high yield next year.

Consequently, in the case of restricted rainfalls, irrigation is important to be implemented before the onset of spring (April – May) and also during the fruit growing in September.

In almost half of the olive groves (48%), irrigation is implemented once a month and the irrigation time lasts 3-4 hours (47%). There are also cases of long duration irrigations, during which there is danger of nutrients losses due to their washoff in deeper layers.

11.1.4 Fertilization

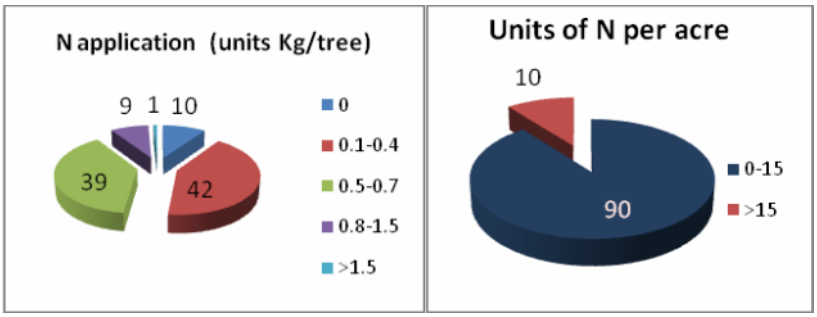
In order for the olive tree to bear fruits in a satisfactory level and be productive, its needs in nutrients should be covered. For the determination of the fertilization method, the tree age, the irrigation possibility and the data received from the soil analysis and leaf analysis should be taken into consideration. As it was mentioned, 81% of the olive groves have not gone through soil analysis. The data below concern olive groves in a productive age and edible olives cultivars (97% of the olive groves) cultivated under dry conditions. In dry olive groves, water shortage restricts the beneficial effect of the fertilizers. In those cases, fertilizers application are recommended to be carried out when soil is fresh, such as after rainfalls.



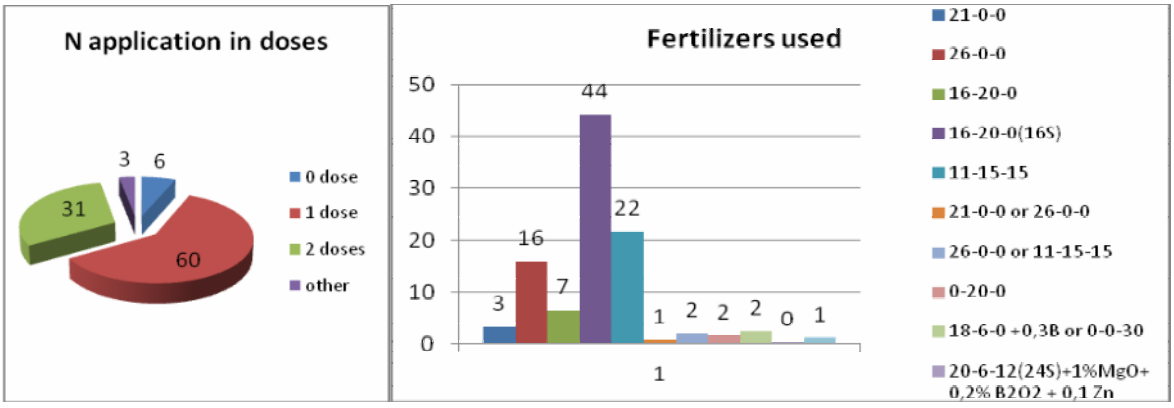
In 87% of the olive groves, inorganic fertilization is implemented. In only a small percentage is inorganic fertilization implemented with the addition of digested manure and only in 2% is organic and inorganic fertilization combined.

The aim of fertilization is for the olive trees to be in an excellent nutritional status. Fertilizations should take place in time, so that the olive trees can have the necessary nutrients, such as nitrogen,

phosphorus and potassium available. In 45% of the olive groves, fertilization with three basic elements, which are Nitrogen (N), Phosphorus (P), Potassium (K). From all the trace elements, the most common deficiency for the olive tree is the one of boron. Boron fertilization is implemented in 26% of the olive groves. It has to be mentioned that the repeated annual administration of high doses of Boron may lead to toxicity. Fertilization including other trace elements is implemented in 6% of the olive groves.



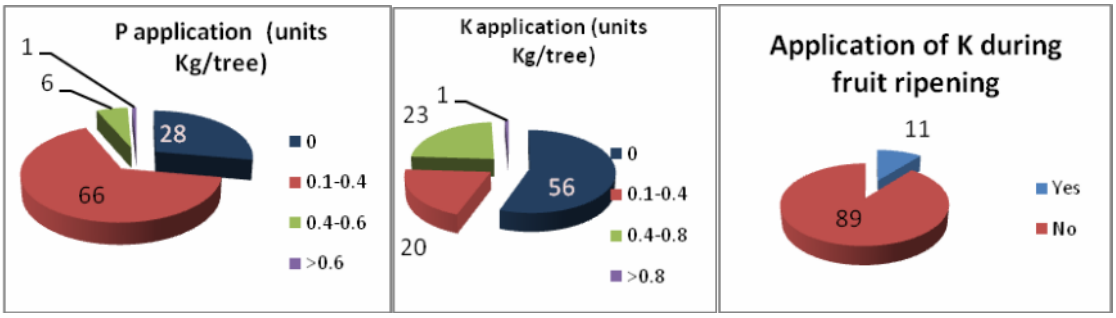
Nitrogen is for the olive trees the most important element and affects growth and fruiting directly. It may also indirectly affect the biennial bearing effects level of the trees. For 42%, the annual Nitrogen implementation ranges in low levels from 0.1 to 0.4 units of Nitrogen per tree. In 39%, 0.5-0.7 units are implemented and in 19% of the olive groves > 0.8 units. In 10% of the olive groves, high doses (over 15 units per stremma) are implemented. The increased quantities of Nitrogen implementation, despite the real needs of the cultivation, may have negative effects, mainly due to the balance overturn between growth and fruiting and the reduced intake of other elements.



The olive tree needs Nitrogen during buds differentiation (February – March), the period of fruiting and setting (April – June) and the period when the pit hardening takes place (July). Usually, Nitrogen fertilization is implemented with one dose only (60%). According to the proper geographical practice code, Nitrogen should be implemented in at least two doses. The first Nitrogen fertilization should be implemented by the end of January – beginning of February, so that nitrogen is available during the crucial period. If the tree does not have the nitrogen needed during spring, many barren flowers are formed and intense fruit falling is observed. Excessive quantity of nitrogen before fruit setting may lead to excessive load and, consequently, to small sized fruit bearing (edible olives) and biennial bearing effects. On the contrary, nitrogen sufficiency after fruit setting will give a satisfactory vegetation length, as well as satisfactory fruti bearing next year.

In 44% of the olive groves triophosphate ammonium is used(16-20-0-16S), while in 22% are implemented with 11-15-15, 16% with calcium ammonium nitrate (26-0-0) and in 7% ammonium phosphate.

In slightly acid soils, basic fertilizers, such as calcium ammonium nitrate, instead of ammonium sulphate or ammonium nitrate for the avoidance of further soil acidification. On the contrary, in alkaline reaction soils, acid-forming reaction for fertilizers should be used.



In 66% of the olive groves 0.1-0.4 units of phosphate/ tree are implemeted. Phosphate favours fruit bearing, olive trees fruit setting and precipitates olives ripening. With the frequent use of complex fertilizers containing this element for several years, soils do not often exhibit phoshorus deficiency and maintenance fertilization is recommended.

Potassium should be implemented in high doses, especially during fruit growth, and is as important as nitrogen for the achievement of high yields. Also, potassium helps the tree to become cold, drought and

fungal diseases resistant. Although the olive tree is favourable to potassium in most of the olive trees (56%), potassium fertilization is not implemented., 0.1-0.4 units of potassium are implemented in 20% of the olive groves and 0.4-0.8 units in 23%.

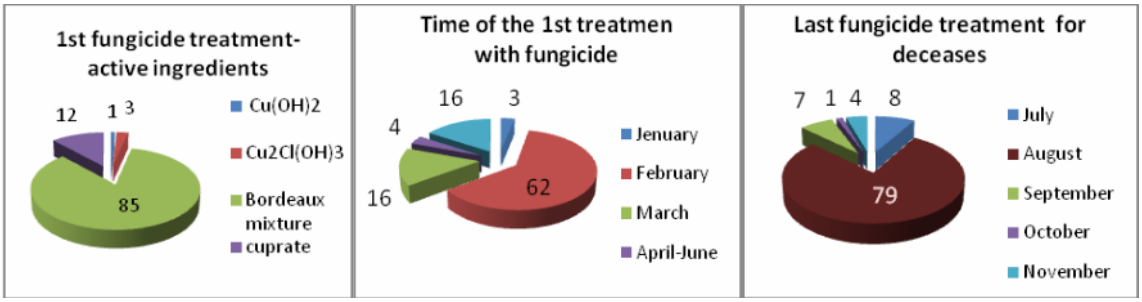
The olive tree is very demanding in potassium, especially during fruit ripening, that is when 60% or even more of potassium is concentrated in it. In a small percentage of 11%, ferilization with KNO_3 is implemented during fruit ripening. Due to the fact that the rapid replacement of potassium that trees use is hard, foliar fertilization with potassium nitrate is recommended in spring and summer.Potassium foliar fertilization may be combined with fungicides.

11.1.5 Plant protection

The complete control of pests is achieved with a combination of various methods, which may concern the prevention of a disease or an enemy intervention, the creation of unfavourable conditions as for pest growth, the measures taking concerning the increase of biodiversity, the protection and enhancementof natural enemies and beneficial bodies. This aims the beneficial weeds to maintain the population of the harmful ones in such levels that they do not cause financial losses. Farming warnings, monitoring and population control of enemies and diseases allow the intervention, when the population exceeds the density tolerance limit. The implementation of chemical substances should only take place when and where it is really necessary and inevitable and since there is no alternative way for weeds control. As many as possible plant covering substances must be used or implemented selectively.

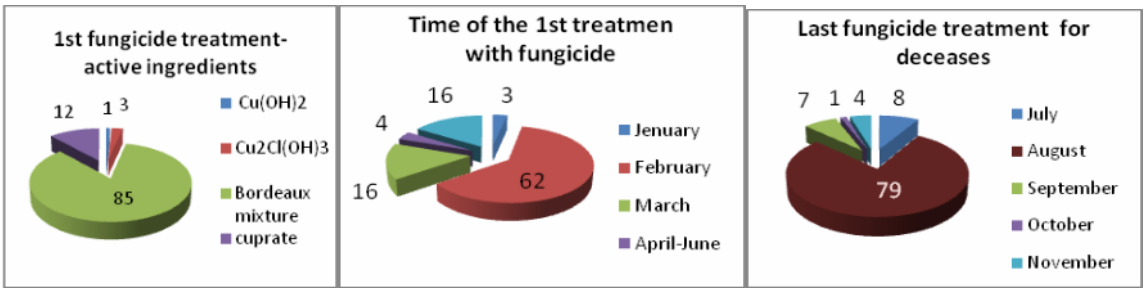
Pests, which usually cause damages and have to be controlled, are olive fly (*Bactocera olea* Gmel: Diptera), Moth (*Prays olea* Bern: Lepidpoptera). Damages may also be caused by Rynchites (*Rhynchites cribripennsis*: Coleoptera), Margaronia (*Palpita unionalis*: Lepidoptera Hb.) and olive Psyllid (*Euphyllura olivine*: Hemiptera-Homoptera). From the diseases, the ones which cause real damages are Peacock Spots (*Spilocaea oleagina*), Olive Soap (*Colletotrichum gloeosporioides)* and Cancer (*Pseudomonas syringae* pv. *Savastanoi* or *Pseudomonas savastanoi*). Also, damages have been mentioned by Verticillium (*Verticillium alboartum).*

In olive groves, 0-7 interventions with plant protective substances are implemented per year, for protection against enemies and diseases, 0-5 interventions with fungicides and 0-5 interventions with pesticides.



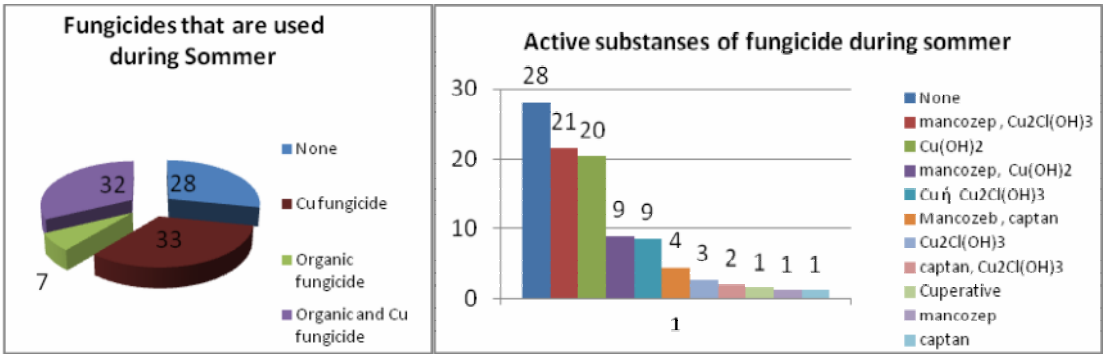
In most olive groves (62%), 3-4 interventions are implemented in total, mainly though with copper and other organic fungicides, for protection against Peacock Spots that infects leaves, as well as Olive Soap that infects fruits and the bacterium that causes Olive Cancer. All these interventions are restricted usually from February up to August (79%).

The first preventive intervention with copper substances for protection against Peacock Spots is achieved in most olive groves by the end of February (65%) before the onset of spring rainfalls, which favour the fungus growth. In this first intervention of the growing period, Bordelaise pulp is usually used (85%). The percentage and rainfall frequency during April, May, June, as well as the risk of the trees being infected, due to the characteristic cultivated cultivars have to drop the infected leaves late, favour the disease spread. For the afomentioned reasons, when after the first operation, an intense rainfall period follows, the fertilizers implementation has to be repeated. The 'Koroneiki' cultivar is more Leaf Spot resistant. From data analysis, it was found that autumn interventions, which are of great significance, are not always implemented, as rainfalls and temperatures during this season are adequate for the pathogen growth. The implementation, that is an intervention and a repeat, if necessary, is recommended in autumn, in the end of September up to the beginning of October, before the onset of rainfalls and after the green olives harvesting. Those interventions should are carried out by only 13% of the producers.

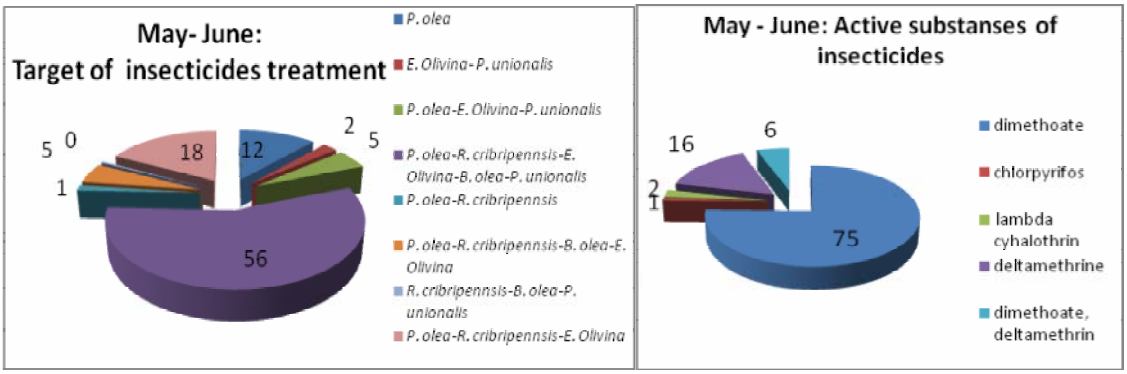


In 28% of the olive groves, no fungicide intervention is implemented. This may be due to the olive grove's location. On sloped areas, air currents that remove excessive humidity are created. However, in wet areas, Leaf Spots may be a restrictive factor for the cultivation, if no measures for its control are taken, because it may even cause a radical defoliation. If this happens during cinsecutive years, it may lead to total barrenness.

During summer interventions (June, July, August), organic fungicides are mainly used, which are alternated with copper ones (33%) or are used exclusively (7%). In 32 % of the olive groves, copper fungicides, such as Oxychloride cu or Cu Hydroxide. A careful analysis of the drastic substances used shows that in 7% of the olive groves, the organic fungicide "Captan", is used, which is not authorized for the olive tree cultivation. The use of non-authorized fungicides is not allowed. Their use may be dangerous for the producer's health.



According to the producers' answers, spraying implemented in May- June aim to control Prays of the Olive (P. Olea 97%), Olive Psyllid (E. olivina 86%), Rynchites (*R. Cribripennsis* 81%), Margaronia (*P. unionalis* 64%), olive fly othe olive (B. Olea 56%). For those interventions, the drastic substance dimethoate (81%) is most commonly used.

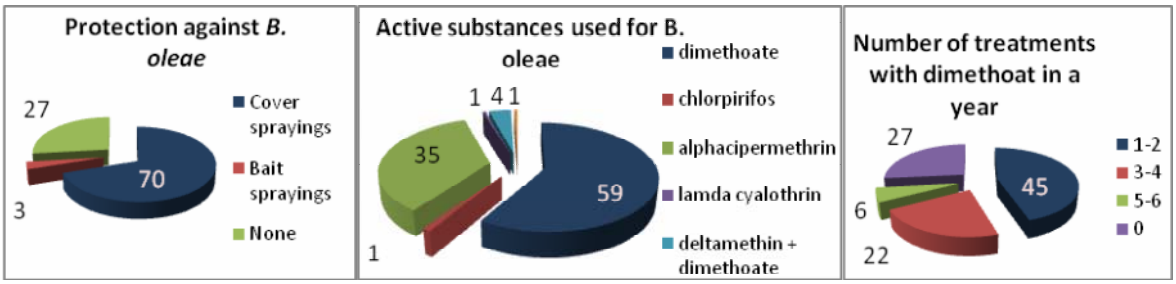


Concerning the prays of the olive, the intervention against the flower generation is necessary in case of a low flower season and high population density. In this xase, it may afflict a high percentage of flowers and decrease the yield noticeably. The use of organophosphoric fungicides againsts this generation must be avoided, because during this period, tbeneficial pests are in activity. Thus, in the beginning of May, when flowers are closed, it is better to use a bacterial formation, which does not kill beneficial insects, such as *Bacillus thuringiensis,* which acts as a fungicide of the digestive system and is safe for humans and the environment. In the case there is olive psyllid threatening population (*Euphyllura olivina)*, a combination of measures taken with the adequate drastic substance is recommended.

In order to control the fruit generation, agricultural bulletins warnings, which inform of the suitable time of intervention against the fruit generation, depending on how early tree give yields in that area, are good to be monitored. Growth regulators, which are mainly selective plant covering substances in comparison with organic- phosphoric carbamate fungicides, can be used against this generation. They should, however, be implemented early with the onset of spawning (egg laying), 5-7 says after the onset of conceiving males in pheromone traps (farm warnings). If trees fruit season is large, the damage from the fruit generation of the prays of olive is significantly restricted, due to the increase of the fruit size. During the season when we have serious infections by Rynchites, a combined control against Rynchites and Prays of the Olive may take place with the use of the adequate active substance.

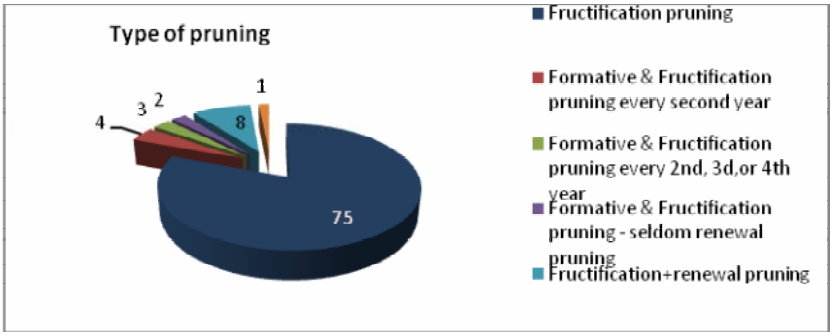
The olive fruit fly (Bactocera oleae) is the most crucial enemy of the olive trees cultivatoons, not only in the areas studied in this survey, but also in all Mediterranean countries, where the olive tree is cultivated. For the protection against the olive fruit fly in 70% of the olive groves studied, full covering sprayings through the use of the active substance dimethoate (59%) are implemented. The

implementation of preventive calendar sprayings of full coverage damage the beneficial insects (predators and pests), so as flares of other harmful insects to be observed.

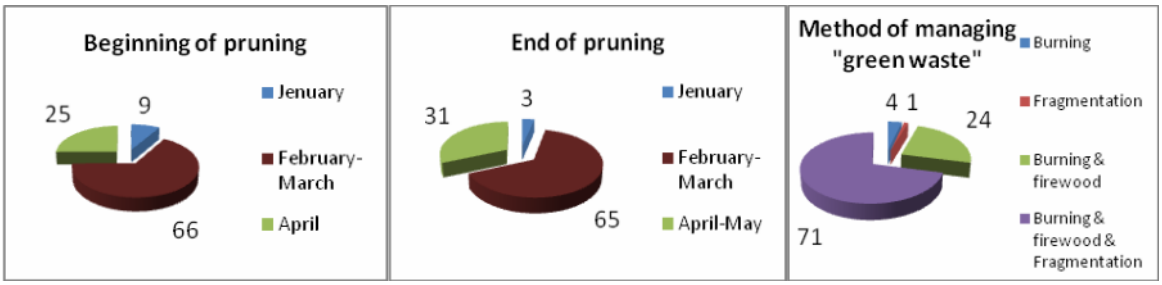


Bait sprayings are implemented only in 3% of the sample. The most suitable season for bait sprayings is determined with the use of olive fruit fly traps, the fruit infection control and farming warnings.Those bait sprayings aim to kill adults, before they lay eggs on the fruit. The addition of repellentshould not be ommited during those sprayings. In case the olive fly population is not controlled with bait sprayings, therapeutic spraying of full covering could be implemented. By controling the number of interventions with dimethoate, it was noted that this active substance is used in 28% of the olive groves more than 3 times a year. This practice may, on the one hand, lead to resistance growth to the insects- target and, on the other hand, harm favourable insects, which maintain harmful insects populations in tolerable levels due to non – selectivity; this entails, among others, the plant covering increase.

11.1.6 Pruning



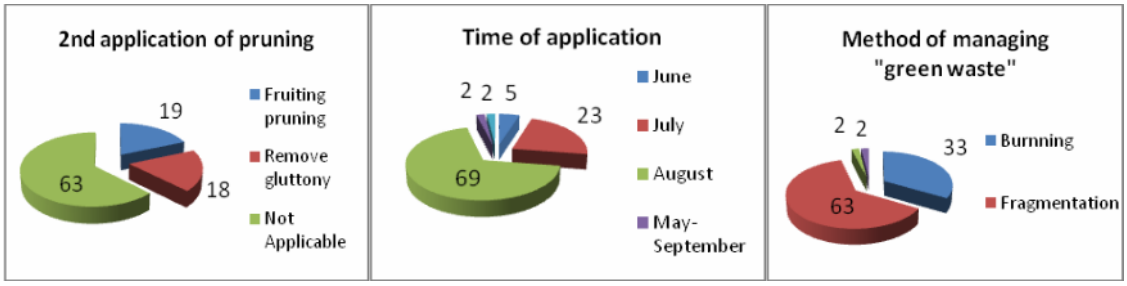
75% of the olive groves got through fructification pruning every year. Fructification pruning is designed to buds thinning, non-productive buds removal and buds that create problems to the internal part of the tree, the olive trees height restriction and the increase of the tree tension to have biennial bearing effects. In this way, the necessary lightning and airing are secured, new cultivation formation is favoured and favourable conditions fro fructificationare created.



In 66% of the olive groves, fructification pruning is carried out in February – March, as soon as the frost risk is over. In areas not afflicted by frost, pruning may be carried out earlier, just after harvesting (9%) and be completed before the onset of the intense circulation of juices, which clashes time- wise with the end of February, in order to avoid the olive tree depletion.

In a significant percentage, the onset (25%) and pruning completion (31%) are over quite late. 10% of the producers, along with fructification pruning, they implement renewal pruning to old non- productive trees or to those the growth of which is far from the soil surface, leading to high costs in pruning, plant covering and harvesting.

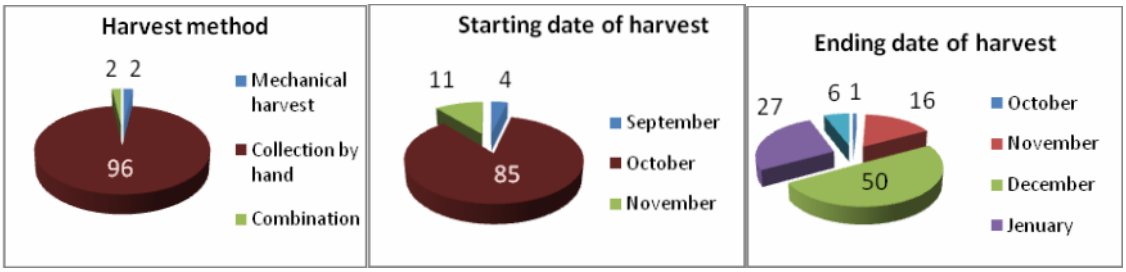
Prunings recycling, through to the process of fragmentation (mechanical damage) and the olive tree deposition to the soil aiming at the increase of its organic substance is a good technique implemented partly and should be encouraged. Exception to the rule is the case of the infection by Vericillium dahlia, which causes hydromycosis of the olive. In every case, biomass utilization, which is removed through prunings, should replace the technique of burning.



A small percentage of the producers (19%) implements fructification pruning during summer months. This technique harms trees in summer, due to the direct sunlight on the trunk and in winter they more frost susceptible. Only in case there is infection by the bacterium *Pseudomonas savastanoi* , which causes cancer of the olive tree, is postponing of pruning during the summer months recommended, so that the bacterium dispersion can be avoided.

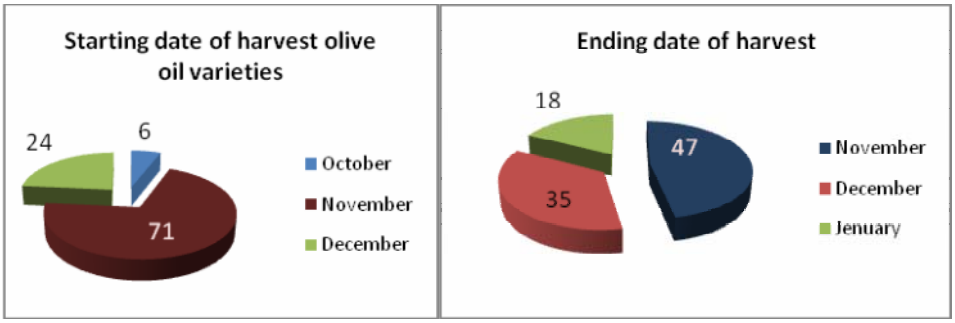
18% of the producers remove insatiable buds (69%) during August. Insatiable budscause problem to the juices circulation in the base of branches and that makes branving need unavoidable. Insatiable buds are valuable for the replacement of the exhausted branches. 63% of the waste is crushed and used for soil enrichment in organic substance.

11.1.7 Harvest



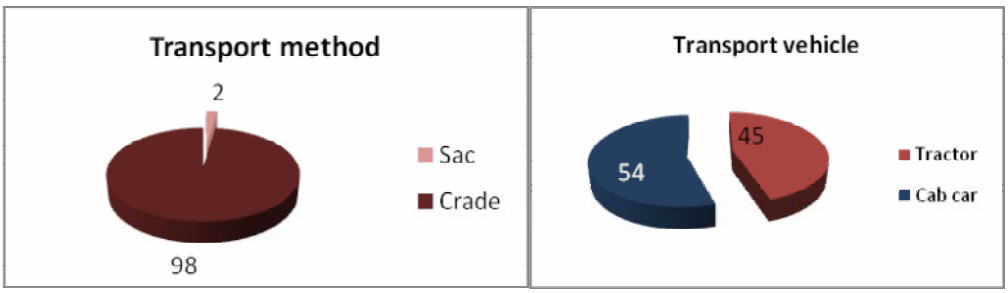
In olive groves cultivated in order to produce edible olives (96%), the fruits collection is carried out by hand, which is collected one by one from the trees. In this way, fruit damage is avoided, but the costs become really high. The green fruit is taken to the store room, where selection through a mechanical olive selector, aiming at removing foreign matters (leaves, branches etc) and its assortment according to size.

Fruit harvest from oil extracting cultivars is carried out by hand or is helped with the help of mechanical means (mechanical harvest). In the case of hand collection, fabric is laid and the fruit is collected with special olive rakes. Harvest by hand is improved with the use of power- driven equipment, olive beaters or vibrators in an adequate maturity state of the fruit, so that many not many leaves fall along with the fruit. With the help of the mechanical equipment, fruits are falling in nets. The use of the equipment helps towards the decrease in the length of the harvest period and work load costs.

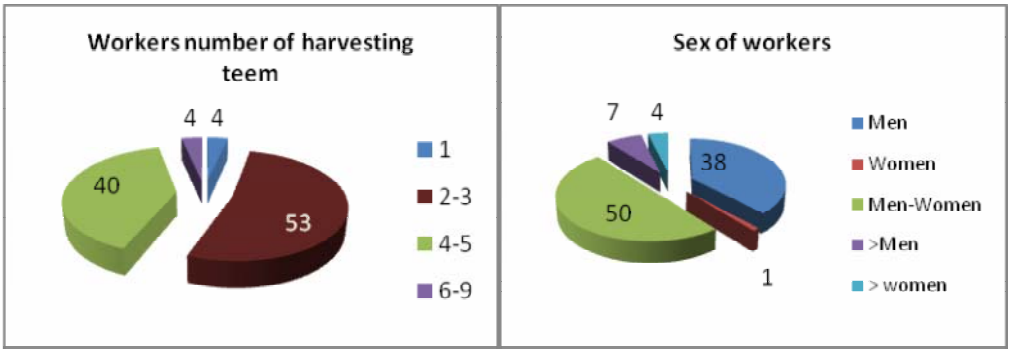


The edible olive is mainly harvested in October (85%). The harvest period starts after the completion of the fruit size and before the flesh gets soft. Green olives are harvested while they are still unripe by the end of September (4%) up to beginning of October, while black olives are harvested later, when they mature and obtain the desirable colour, but before they get soft.

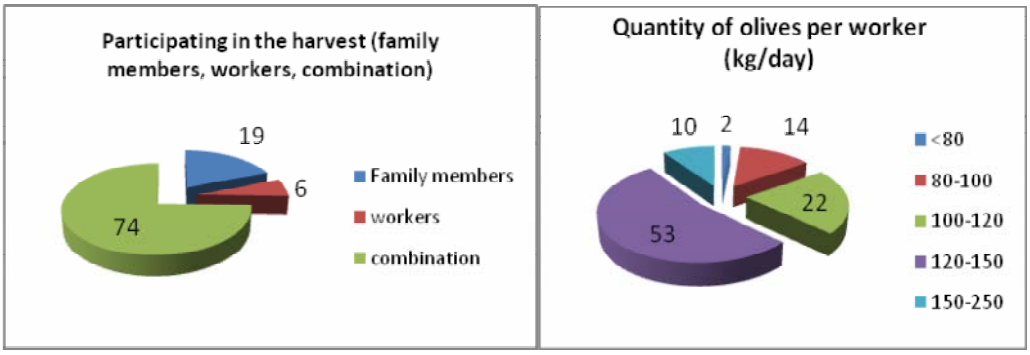
In olive oil extracting olives, harvest may start, when the colour starts to change and be followed, depending on conditions and possibilities, until the fruit gets black. Earlier harvest gives less and of higher quality oil, while later harvest, when fruits have over matured, gives a higher percentage of oil content. The onset of harvest in most olive groves starts in November (71%) and ends in January (18%).



The most important issue during the olive fruit transport is its protection against compression, due to excessive heaping, and any damage or bruise. Crates (98%) is a good way of transport, since the fruit is not injured, while airing of the olive fruit is made easier. The olive fruit transport is carried out either with farming vehicles (54%) or tractors (45%).



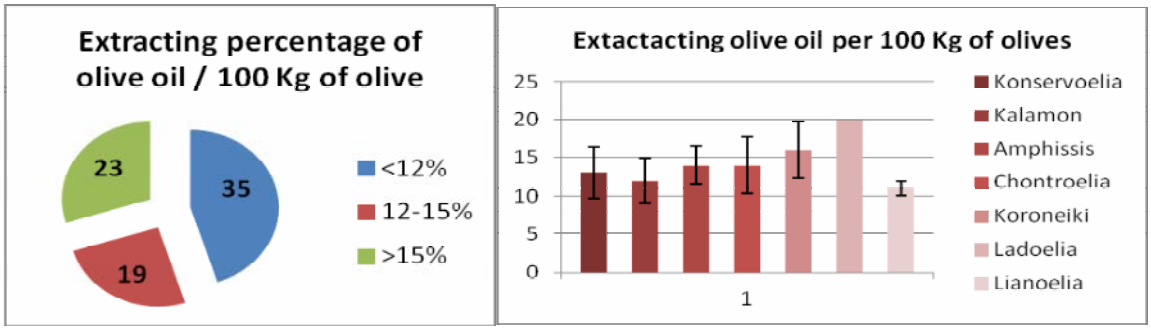
During olive harvest, members of the family, as well as workers (74%). Teams are constituted mainly by 2-3 (53%) or 4-5 persons (40%), which are made up of men and women only. Every worker usually harvests 120-15 kilos of fruit (53%).



11.1.8 Final Products & Olive Oil Extracting

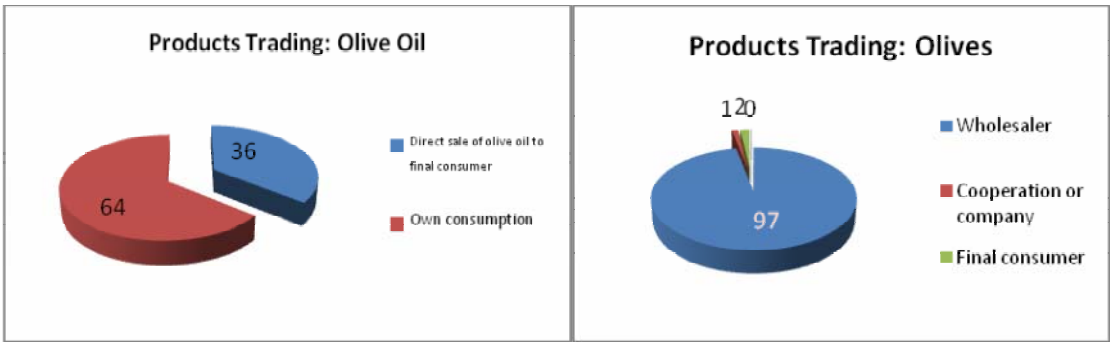
From 80 producers' olive groves which make up the sample, 480.3 tn of edible olives and 26.8 tn of olive oil are produced on average annually. The oil yield ranges in a percentage of <12% for 35% of the olive groves, 12-15% for 19% and in a percentage higher than 15% in 23% of the olive groves. Low oil yields

may be due to the collection time length of the fruit. Most cultivars are edible and a big part of the fruit is collected when the fruit is still green. The small- sized or of a low commercial price green fruit is used for olive oil extracting. In this stage, oil content is low. Acidity ranges for 99% of the produced oil between 0-0.3 and is characterized as extra virgin oil.



11.1.9 Products Trading

36% of the produced oil quantity (9.2 tn) are packaged in containers of 16 lt and are dosposed straight to the final consumer. The selling price ranged on average between 5€ in 2010 and 4.86€ in 2011. 64% of the olive oil produced (16.6 tn) is used for the same consumption.



96.9% of the edible olive (464 tn) is given on average every year to wholesalers and more specifically:

- 368 tn of the edible cultivar 'Konsrvolia Artas' as a PGI product.
  - The sales price ranged in 2010 between 0.4 upt o 1.2 €/ Kg and in 2011 from 0.35 up to 1.1 € /Kg, depending the maturity size and degree.
- 45 tn of 'Amfisis' cultivar 0.9 € / Kg in 2010 and 0.95 € /Kg in 2011.
  - 42 tn of 'Kalamon' cultivar 1.25 € /Kg in 2010 and 1.36 € /Kg in 2011.

1.2% of the edible olives fruits (5.75 tn) are given to a cooperative or business (as PDO, PGI):

- 5.3 tn of 'Konservolia Artas' priced 0.75-1.10 € / Kg in 2010 and 0.65- 1.1 € / Kg in 2011
- 0.45 tn on 'Kalamon' cultivar priced 0.6 – 1.3 € /Kg in 2010 and 2011

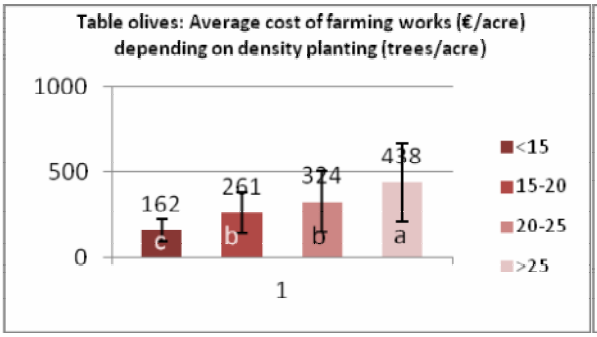
1.8% (8.5 tn) Straight edible cultivars sale to the final consumer (Sale towards PDO, PGI)

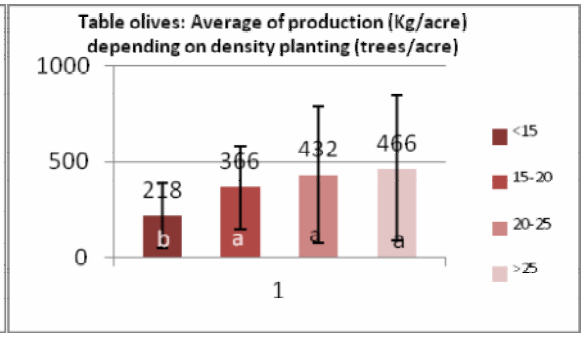
- 4 tn of 'Konservolia' cultivar priced 2-2.5 € / Kg in containers of 3,5,6,13 € / Kg
- 4.5 tn of 'Chondlrelia' cultivar from which
  - 2.5 tn priced 2.5 – 3.5 € / Kg in 2010 and 2.2- 3 € / Kg in 2011 and
  - 2.1 tn with average 1.5 € / Kg in 2010 and 2 € / Kg in 2011 in plastic containers of 10 Kg.

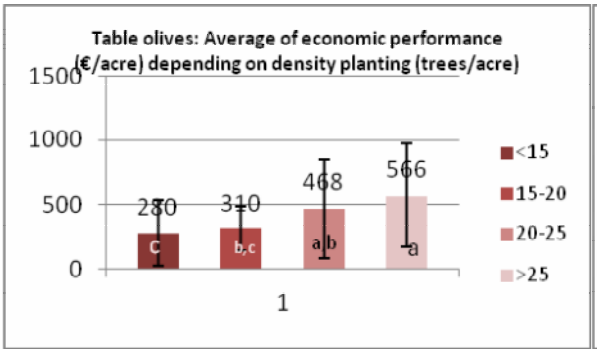
0.1% (0.5 tn) is used for the same consumption

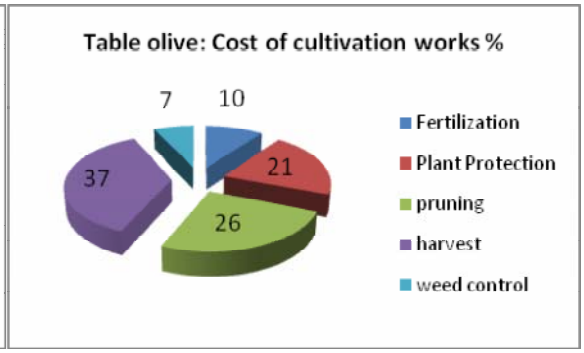
11.1.10 Production cost of table olives

In order for a business to be profitable, except for the section of sales, it is important to have low production costs. The complete management aims to the production of quality products through the implementation of the suitable farming activities and techniques that help the plant covering interventions decrease, the more proper utilization of the pesticides and, generally, the decrease in production costs. Another factor that affects the costs is the cultivation system implemented. Traditional olive groves with plantation smaller than 15 trees per stremma are characterized many times by absence of systemic cultivation. Cultivation costs of the olive groves (162 ± 64 € / stremma) is statistically significantly less compared to that of the more intensive olive groves depicting a larger plantation density, more inflows (pesticides fertilizers) but lower yields accordingly (262 ± 167 Kg / acre) and cultivation income (280 ± 252 € / stremma). With data analysis, it is assured that harvest (37%) is the most expensive activity in the olive grove.









11.1.11 Production cost of olive oil

Due to the fact that olive groves directed to oil production are only a small part of the olive groves of the area studied and the sample number is small; there are both irrigated and non- irrigated olive groves of different age group and different cultivars. In this case, data analysis would not give us a representative picture of the average situation. Based on data analysis, cultivation costs reaches on average 206 ± 121 €.

11.1.12 Question regarding development and collaboration disposal

91% of the producers desire further co-operation in the framework of the program. The largest percentage of the producers considers that the future of the area olive production is ominous and disappointing.

According to the producers' opinion, the advantages of the area in the olive production area are the good soil- climate conditions and the existence of modern olive mills in the area. Olive groves are usually installed in semi- inclined and semi-mountainous areas, where cold currents escape. The disadvantages

are soil erosion in very inclined areas, the lack of irrigation possibility and manufacturing and packaging units, the high percentage of humidity in certain lowlands, which favour the growth of diseases, such as affliction by the olive fruit fly.

In the question: What can you do in order to improve the cultivation efficiency ?, many producers believe that through soil analysis, the fertilization method they are going to use will be more effective, they mention the necessity of infrastructure creation for the olive groves irrigation, the construction of terraces, the necessity for proper guidance by experts, the early implementation of the adequate cultivation activities, the cultivation cost decrease, the co- operation with other producers for creating manufacturing units and the product marketing. Certain producers consider that they cannot do anything about it.

In the question: What can authorities do to improve the cultivation efficiency?, many producers mention the subject of information, updating and guidance by experts (the union, the cooperatives, the Directorate for Agriculture), the seminars organization, the subsidy for terraces construction, the exports forwarding.

65% of the producers is interested in the vertical integration of his/ her unit throught the creation of an olive mill and the foundation of an olive oil packing centre. 67% is interested in vertical integration and the foundation of an olive processing and packaging unit. All producers have submitted or implemented an investing program concerning the utilization of his/ her olive grove.

82% of the producers is interested in exporting his/ her producting quantity of edible olives and 72% of the produced oil, while 87% is interested in certifying his/ her unit as PDO or for co-operation and help in the disposal of the produced product.

From the produced edible olives, the ones which are difficult to be utilized are the infected ones by the olive fruit fly, blonde olives and small-sized olives. Problems are also created during years of high yields.

Concerning the oil utilization, most producers mention a problem to the utilization of the whole produced quantity,as well as to the utilization of high acidity olive oil, due to its degraded quantity. Based on the producers' opinion, the right and early application of farming activities, the implementation of the adequate fertilization and the irrigation possibility of the olive groves, according to the soil analysis the application of the adequate plant covering interventions and the irrigation possibility of the olive groves coulf help the produced quantity of edible olive. There are producers that relate the high price of pesticides with the non implementation of certain cultivation methods, which

affetcs the fruit yield negatively. According the quality improvementof the produced edible olives, producers highlight the significant role of the experts towards their updating of information, as well as their proper guidance and supervision in matters related to fertilization, plant covering and the implemented cultivation methods in general. They highlight the subject of the proper use of pesticides, so that there are no pesticides residues in the fruit and the produced olive oil. Also, they consider that the protection against the olive fruit fly, the adjusting of the fruit size, the irrigation possibility, the implementation of soil analyses will help towards the improvement of quality of the prduced edible olives.

Producers mention that the fruit collection after mid- December, the proper updating by experts and the application by experts and the implementation of the proper cultivation method, may help towars the increase of the produced oil. The opinions concerning the irrigation effect to the produced quantity of oil are ambiguous. Most producers believe that irrigations help towards the increase of the produced olive oil, while others think that the restriction of irrigations increases the content in oil. It is true that fruits from irrigated olive groves give low yields in oil % of fresh weight, but due to a bigger relation between flesh and pit, they give higher yields in oil.

According to the producers' opinion, the production of health fruits and especially the protection against the olive fruit fly, the proper cultivation methods, the use of the proper pesticides, the production of fruits with no pesti9cides residues, the early transfer of the fruits after harvest to the mill, the adequate sacs for its transport, the proper guidance and suprvising by experts help towards the increase of the produced quality of olive oil.

11.1.13 Characterizing olive produced exploitations

The average number of olive trees per olive produced exploitation is 405 ±268 trees, the average plantation density 18 ± 4 olive trees, the average total extent per producer is 23 ± 15 stremmas consisting on average of 3 ±2 agricultural parcels. The cultivation cost reaches on average 259 ± 133 € per stremma and the financial efficiency ranges on average between 306 and 240 € per stremma. Referring the efficiency characterization, the cultivation cost was estimated by estimating the personal workout and the income received from thee production or the same consumption of the produced products. In case where the income was more than the cultivation cost, the cultivation efficiency was

characterized as sustainable. According to data analysis, 50% of the olive producing cultivations were characteized as sustainable.

12 New recording of the most effective cultivation techniques of the producers according to the survey

- In the olive gorves of the area studied (95%), the method of non farming is applied. Through this method, soil erosion is avoided in inclined areas, as well as roots wounding, which causes favourable conditions for the tree inflictions by the bacterium *Verticillium*. Pests are controlled through the use of pesticides or through their cutting before they flower, so as not to compete olive trees in water and nutrients.. They stay on the soil and create a protective layer that helps the maintenance of soil humidity.
- Soi analysis, which has been carried in a small percentage of olive groves (19%), is a tool which helps the decrease of the production cost or throgh the implementation of the necessary nutrients only, the avoidance of the aimless or excessive fertilization, the selection of the suitable type of fertilizer, the implementation of the adequate fertilizing dose depending on the degree of intensification of the olive groves and the previous yield.
- In almost half of the olive groves (45%), fertilization with the three basic elements Nitrogen (N), phosphorus (P), potassium (K) is carried out. From the trace elements, the most common deficiency for the olive tree is the one of Boron. Fertilization with Boron is implememnted in 26% of the olive groves.
- In most olive groves, the first fertilizing dose is applied up to the beginning of February, so that nutrients can be available during the crucial period.
- In a significant but relatively small percentage of olive groves (30%), nitrogen is implemented in more than one doses. The olive tree nitrogen demanding during buds differentiation. (February – March), The flower period and setting period (April – June) and during the season, when pit hardening takes place (July).
- In a small percentage of 11%, aditional fertilization with KNO_3 is implemented during the fruit ripening, usually through foliar analysis. Potassium is necessary in big quantities, especially during fruit growth and is equally important for the achievement of staisfying yield efficiency.
- By the end of February, before the onset of rainfalls of the spring, preventive intervention is carried out in most olive groves (65%) with copper substances for the protection against leaf spot.

The conditions prevailing during this season favour the bacterioum growth. In this first intervention of the cultivation period, bordelaine pulp is usually used (85%).

- From the data analysis, it was proven that in a small percentage of the olive groves (13%), autumn interventions were implemented for the protection against leaf spot. In wet areas, autumn interventions are necessary for the protection against leaf spot, because humidity due to rainfalls and temperatures during that period are suitable for the pathogen growth.
- A significantly small percentage of the sample (3%) implements bait sprayings, in order to control the olive fruit fly. Those sprayings aim to kill adults, before they spawn on the olive fruit. The suitable season for the implementation of bait sprayings is determined with the use of olive fruit fly traps, the control against fruit infestations, the control against fruit infestations and farming warnings. In bait sprayings, the addition of attractant in the sprayings substance is not omitted. In case where the olive fruit fly population is not controlled with bait sprayings, therapeutic spaying of full coverage is implemented.
- In 75% of the olive groves, fruit pruning is implemented every year. Fruit pruning aims to the buds thinning, the removal of non productive buds and buds that create problems in the internal parts of the trunk, the restriction of height of the olive trees and the decrease of the tendency of the tree to present biennial bearing effects. Thus, the necessary lightning and airing is secured to the olive groves and new growth conditions for fruiting and unfavourable conditions for coccoids growth appear.
- In 66% of the olive groves, pruning takes place in February – March, after the frost risk is over. In areas that are not in the risk of frost, pruning is carries out earlier, straight after harvest (9%) and is completed before the onset of the juices circulation, that clashes with the end of February, in order to avoid the olive trees depletion.
- Prunings recycling through the process of fragmentation (mechanical destruction) and the deposition in the soil of the olive grove, in order to increase its organic substance is a good technique that is implemented partially and should be encouraged, too. Exception to the rule is the case of infestation by the bacterium *Verticillium dahlia* and *Pseudomonas savastanoi* that causes cancer of the olive tree.
- 18% of the producers remove during summer (69% in August) insatiable buds. Insatiable buds in the beginning of branching cause problems to the juices circulation and the need for pruning is

imperative. Insatiable buds on the bending points are valuable for the replacement of the depleted branches. 63% of the residue is fragmented and used for the enrichment of the soil in organic substance.

- The fruit is removed in crades (98%). The transfer in crades is recommended, because the fruit is not injured, while the olive fruit airing becomes easier.

13 Comparison of the producers' most effective cultivation methods based on the survey and of those which result from the bibliography

- Soil analysis is necessary to be carried out in all olive groves. Based on the results of the soil analysis, the most adequate type of fertilizers is selected. In slightly acidic soils, basic fertilizers, such as calcium ammonium nitrate, instead of sulfuric or nitrate, in order to avoid further soil acidification. On the contrary, in alkaline reaction soils, fertilizers of alkaline reaction should be used.
- For the determination of the trees fertilizing needs in nutrients, various factors are taken under consideration, such as the nutritional condition of the tree, the soil humidity available, the age and plantation density. A tool for monitoring the nutritional condition of the trees is leaf analysis.
- The use of simple fertilizers allows the better utilization of the basic nutrients administration, in comparsison with the use of compound ferilizers, because the implementation of phosphoric and potassium fertilizers in autumn and nitrogenous ones in the end of winter is possible.
- Concerning the nitrogen fertilization, it is mentioned that the level of the administered nitrogen should not exceed 1.5 Kg N/ tree or 15 Kg N/ stremma.
- For the control against the disadvantages of the high plantation density, which is related to the creation of favourab le conditions for the expansion of enemies and diseases of the olive, the transfer of the fruit zone of the tree on the higher levels of the tree and the reduced production, the uprooting of certain trees is reccomended, so that no problem is observed from the intense competition of the trees and the excessive shading of their canopy. In modern olive groves of high plantation intensity, the appropriate design of installation that will allow its thinning in future should be provided.
- For very inclined soils (25-30%), the terraces construction for soil protection against erosion is recommended. The structure of terraces presupposes topographic and soil survey for the extent and depth that the soil activities are goingt o take place.

- Weeds will have to be controlled early, so as not to conpete olive trees in water and nutrients. The species of weeds of the olive grove should be checked and every time the equivalent way of control be used.
- In general, the mechanical soil activities should be restricted in the minimum and only if its implementation is necessary. For surface soil activities and the destruction of annual weeds, it is good to avoid the use of rotating machines (milling machines) and a light cultivator or a toothed harrow. Also, the exclusive use of the milling machine should be avoided in olive groves with perennial weeds and alternatively, plowing should be implemented. As for the common working of the soil, plowers should be used. The depth of the working of the soil in spring should exceed 0-10 cm , if it is considered to be necessary.
- In areas such as the one studied, with a high percentage of rainfalls during winter, artificial soil plant covering during winter should be encouraged with sowing the appropriate plant species (graminaceous plants, leguminous vegetables or a combination of the two) in autumn, dependind on the target of green manure (humification, mineralization). The plant material is incorporated in the soil (green manure) by the end of winter, or is dried with a postmergence pesticide, either it is cut mechanically or left on the soil surface.
- During years or restricted rainfalls during spring and autumn, the irrigation implementation is proposed before the onset of flowering (April- May) and also during fruit groeth in September.
- The technique of surface drip irrigation is recommended for the olive tree irrigation.
- During years when big fruit setting is observed, fruit thinning may be implemented to the olive tree, as well as other fruit growing trees. Through this technique, part of the flowers or fruits is removed, excessive fruiting, which leads to the tree depletion, the forming os small-sized fruits and the intense biennial bearing effects of the tree, is avoided.
- Fructification pruning in table olives, if implemented in the right way, may improve the size of the fruits through the adjusting of the load it succeeds. For this goal, thinning of fructification branches during years of excessive fructification is recommended right after fruit setting.
- In order to determine the harvest time, factors, such as the risk of infestation by the olive fruit fly and the harvest escalation that the producer is enforced to carry out so as to ensure the necessary working hands and the smoother operation of the mills should be taken into consideration. Also, the effect that the harvest time has in the fructification of the next year should not be ignored.

The delay of harvest for better fruit oiling is considered to have unfavourable repercussions to the differentiation of the inflorescences of the next year.

- The complete management of pests is achieved through the combination of various methods that, among others, include the measures taking related to the protection and enhancement of natural enemies and beneficial organisms. This aims for adults to retain the population of harmful organisms in such levels that they do not cause any financial damage. Except for the determination of the appearance of the cultivation enemies, knowledge and natural enemies control are of great importance, too.
- In a survey that was carried out in olive groves of the area of Arta- Preveza (Patakioutas etc, 2009) the presence of the predator *Anthocoris nemoralis Fabricius (Hemiptera: Anthocoridae),* which is possible to restrict the growth of the population of pseudococcus and is a predator of the larvae of the flower generation of the moth (*Prays olea: Hyponomeutidae).* The predator bugs of the family coccinellidae Exochomus quadripustulatus L. and Chilocorus bilistulatus restrict the growth of the black scale olive. The predator of the olive fruit fly Prolasioptera berlesiana Paoli and hymenopteron parasites Prigalio mediterraneus Ferrière and Delucchi and Eupelmus spp. do not have the ability to be factors of satisfying restriction of the bug. Also, a big number of Neuroptera of the families Chrysopidae and Hemerobiidae, as well as species of the Raphidiotera, which decrease the populations of harmful bugs, were detected.
- Population monitoring and control of the enemies and diseases allow the intervention, when the population exceeds the limit of tolerable density. The implementation of chemical control should take place only when and where it is really necessary and unavoidable and since there is no alternative way of control. Selective plant covering substances should be used as much as possible or be implemented in a selective way.
- During years of high yield, the intervention for the control of the flower generation of the moth is not recommended. If fructification is low and the population density high (over 20% of the fluorescences infected), the intervention against the flower generation in the early stages is unavoidable (early spring, when 4%-5% of the buds has opened with the use of the proper means of plant protection.). The use of organophosphorus pesticides against the flower generation should be avoided,as during this period, beneficial bugs are active. It would be more preferred to use a microbial substance that kills beneficials, such as Bacillus thuringiensis, which acts to the digestive system of the bugand is safe for human and the environment. If, except for the moth, an

infection by rynchitis is observed, a combined control against the two enemies during the early stages with an adequate organophosphorus pesticide eg Dimethoate is proposed. In the case that there is an infestation not only ny moth but also by pseudococcus, a combined control of the two enemies with the suitable pesticide, eg Deltamethrin is proposed. In areas, where the moth causes damages every year or fructification is restricted, a second spraying against the fructification generation of the moth with the sutiable pesticide that belongs to a different group is proposed. For the control against the fructification generation, it is positive to observe the farming bulletin warnings **www.minagric.gr /index.php/el/for-farmer/agricultural-warnings/ 134-ioannina.html** which inform about the proper time of intervention according to how early the area yields.

- In order to control the olive fruit fly, two natural, biotechnological and chemical methods can be combined. Trapping en masse combines a food attractant, pheromone and an adequate pesticide. Adults are attracted, come into contact with the surface that has been soaked with pesticides and they are killed. The use of glass traps of Mcphail type allows the monitoring of the first appearance and the variance of the population of the olive fruit fly. The implementation of bait sprayings is based on trapping the olive fruit fly in the traps and are effective when they are implemented earlier in the wider area. Therapeutic cover sprayings are implemented when the infestation percentage exceeds 2-4% for the olive produced olives and 0-1% for table olives.
- Organophosphorus Dimethoate is used in the area, as in many Mediterranean countries, for many years. The tension and frequency of sprayings create an intense selective pressure that leads to the appearance of tolerant populations. This leads, on the one hand, to the increase of the control cost, due to the implementation of more frequent interventions with higher concentration, the revision of sprayings with a different active substance, the decrease in yields due to fruit infestationby the tolerant population, as well as environment side effects. On of the targets of the complete management is the detterence of tolerance appearance. This target may be achieved through the implementation of alternative measures and the minimization of chemical means use. The switching of pesticides use in a different way of acting and the use of pesticides of a small residue are measures that help the tolerance increase.

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15 Appendixes

APPENDIX I: List of olive producers who co-operated in the framework of the program for the questionnaire completion

APPENDIX II: Questionnaire

APPENDIX III: Answers codification

APPENDIX IV: Codified answers