ORGANIC OLIVE FRUIT AND OLIVE OIL PRODUCTIONS

GREENFOOD PROJECT

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1. Introduction

Differences between organic olive oil production and conventional or integrated farming remain on agricultural methods followed in the olive grove. Similarities reside in the elaboration process at the press mill.

The general principles and practices of Organic Farming (OF) are defined in EU legislation, mainly in the Council Regulation (EC) Nº 834/2007 and in the Commission Regulation (EC) Nº 889/2008. These regulations include all agricultural crops, animal production and also olive fruits and olive oil production in organic farming. This legislation also comprises rules for monitoring and certifying products as organic (Organic Farming) and the indication of the Certification Body, either public or private.

For Portugal and for most EU countries the certification control is carry out by Private Certification Bodies (PCB). These bodies are approved by competent authority of each Member State and accredited by the agricultural ministry of each country. The PCB must follow the European Standard EN45011, which requires in particular the independence from the operators (producers, or others) and assumes the compromise of do not provide technical assistance. The PCB must also submit a monitoring plan that ensures consumer the guarantee of the entire production process, from farm to packaging and labeling. Apart from the annual schedule control visit, the PCB should make a second visit, not planned, according to the annual control plan. If this second visit doesn’t have place, strongly undermines the credibility of the inspection system and certification. In addition to monitoring visits, the PCB should also collect samples for analysis to detect possible frauds. Regarding olive fruits and olive oil, the analysis should focus especially on not allowed chemical synthetic pesticides residues. For olive oil, the research should center on lipid-soluble pesticides. In olive fruits and olive leafs should be made a more general research on the most active substances applied to conventional and integrated olive production.

The organic olive oil is a high quality product, highly valued if compared with further kinds of olive oil obtained in other production systems. This valorization may exceed 100% in demanding markets, where this price-premium is accepted. Nevertheless, a presence of a credible and competent PCB is fundamental to maintain reliance on organic products. However, most demanding costumers (retailers and wholesalers) do not merely accept such control, in part because of its own limitations. These clients come to visit the producers, or send their own representatives to meet the producers and the production units and usually take samples for analysis of residues (pesticides and others). Recently, a producer was forced to replace the plastic tubes of the mill press, since a customer has found phthalates in olive oil, even if if small quantities, after asking for a laboratory analysis. Phthalates are endocrine disruptors and, therefore, dangerous to health.

In addition to organic certification, there is also a more selective and demanding market for products from biodynamic agriculture. Rules for biodynamic agriculture are private and require producers to adopt a second period of conversion (organic to biodynamic), namely use biodynamic preparations on soil and compost, and reduce the maximum annual doses of copper by 50%, i.e. 3Kg/ha, instead of 6Kg/ha.

2. Organic production of olive fruits

The organic olive fruits production is possible in different types of olive groves:

- Olive grove in organic farming - first harvest can be certified;
- Conventional or integrated olive grove converted to organic farming – must undertake a conversion period of three years.

In this conversion period, all organic farming rules must be fulfilled, although the final product (olives or olive oil) cannot be marketed as such. This is the most difficult period for the producer, which requires more support, both technical and financial.

In organic farming, intensive production systems are allowed, since soil is used, rather than hydroponics techniques. Nevertheless, highly intensive systems are difficult to apply as it does not match some organic farming principles: priority use of farm resources; maintenance and improvement of soil fertility; natural pest limitation instead of phytosanitary treatments; disease’s prevention through prophylactic measures, such as tree density not causing excessive shading. To match these principles, a maximum of 300 trees per hectare is accepted for an organic olive grove (Fig. 1).

Fig. 1- Semi-intensive olive grove, with 300 trees per hectare and covered soil to prevent erosion (Serpa, Portugal, 2008)

2.1. Soil preparation and management

The unused of forbidden fertilizer or pesticide is not enough to assure organic farming. To achieve this, farmer must use practices and techniques to maintain and improve soil's fertility. This is a basic principle, which must also be evaluated by the PCB, which is not always the case.

The installation and maintenance of a new olive grove, requires the following principles and practices:

1) Soil must be evaluated until 1 meter depth at least in order to identify the main fertility aspects, which requires the opening of profiles to observe and collect samples for analysis;

2) The soil must be mobilized in depth (about 1 meter) without turning around the different layers, and in accordance with the observation made before, which is achieved through the practice of ripping, then pass with chisel, or tine cultivator or combined machine of spring-loaded tines with straw incorporated discs (which is the case of PolyMag) (Fig. 2);

Fig. 2 - Combined machine of spring-loaded tines with straw incorporated discs to prepare the soil with fewer passes and less fuel and energy consumption

3) Before the olives trees plantation, soil must be cleaned out of weeds that are more difficult to combat without herbicides, particularly rhizomatous herbs, such as bermudagrass (*Cynodon dactylon* (L.) Pers.), torpedograss (*Panicum repens* L.), or other perennials, that are difficult to combat, such as sedge (*Cyperus rotundus* L.). This "cleaning process" can be achieved through multiple passes of a spring-loaded tines machine on summer and/or soil solarization in the case of sedge. It is still possible to use a specific pig's breed, named "montanheira", explored in extensive production system, without nose rings, so they can excavate and remove the weeds and eat them;

4) Soil fertility must be improved since the first year of plantation, through organic and mineral correction, when the main parameters of fertility are outside of the favorable values (Tab. 1). This can be done with an authorized organic corrector, preferably obtained by composting, and with a magnesium limestone (dolomite) or sea source limestone as the *lithothamne*;

Tab. 1 - Analysis of soil chemistry and physics - values and favorable conditions for olive

Parameter	Favorable value	Favorable conditions
Soil depth	>0,8m	Arable soils with more than 1,20 meters are the most appropriate
Texture		Loam, silt loam, clay loam, silty clay loam
Drainage		Good drainage, without accumulation of stagnant water
pH	5,5-8,5	Optimal pH: 6,0-7,5
Salinity/ conductivity	<2,7 dS/m	With 4dS/m there is a decrease in production of about 10%; with 5dS/m, 25%; and with 8dS/m, 50%
Organic matter	>1,5%	Values below 1,5% strongly increases the risk of shortages and loss of fertility
Phosphorus oxide (P_2O_5)	>25mg/Kg	
Potassium oxide (K_2O)	>50mg/Kg	
Calcium oxide (CaO)	>100mg/Kg	
Magnesium oxide (MgO)	>20mg/Kg	
Active lime	<10%	

5) Green manure is a main practice on the improvement of the soil. In the first year should be made an annual green manure made of, at least, one leguminous and one grass specie, according to the type of soil and climate (Tab. 2);

Tab. 2 - Green manure – Autumn/winter consociations for olive grove for different soil types

Species	Seed (Kg/ha)	Soil
Oat + common vetch *Avena sativa + Vicia sativa*	100+50	tiny acid to slightly alkaline; loamy to clay
barley + common vetch *Hordeum vulgare + Vicia sativa*	100+50	neutral to alkaline; loamy to clay
barley + fababeans *Hordeum vulgare + Vicia faba* var. *minor*	100+50	neutral to alkaline; loamy to clay
barley + common vetch + Persian Clover *Hordeum vulgare + Vicia sativa + Trifolium resupinatum*	50+40+10	neutral to alkaline; heavy and difficult to work
Oat + barley + common vetch + fababeans *Avena sativa + Hordeum vulgare + Vicia sativa + Vicia faba* var. *minor*	50+50+25+25	tiny acid to slightly alkaline; loamy to clay
Rye + yellow lupin *Secale cereale + Lupinus luteus*	100+50	acid, sandy, loam and well-drained soil
Rye + common vetch *Secale cereale + Vicia sativa*	100+80	acid, sandy, loam and well-drained soil
Oat + yellow lupin *Avena sativa + Lupinus luteus*	100+50	acid, sandy, loam and well-drained soil
Oat + white lupin *Avena sativa + Lupinus albus*	100+80	acid to neutral, sandy to loamy, well-drained

6) In organic farming, soil conservation is mandatory, avoiding all types of erosion, and water erosion in particular. The best practice to achieve this

goal is by covering the soil, either with spontaneous vegetation (Fig. 3), or with specific cover crops adapted to soil and climatic conditions (Tab. 3);

Fig. 3 – Natural soil covering with spontaneous vegetation based on burclover (*Medicago polimorph L.*), a spontaneous annual alfalfa, very common across the country when herbicides are not applied, in a olive grove in Douro region (Peso da Régua, Portugal, 2011)

Neutral and clay soil	**Seed (Kg/ha)**	**Acid soil**	**Seed (Kg/ha)**
Medicago polymorpha	3	*Trifolium subterraneum*	5
Medicago rugosa	3	*Trifolium vesiculosum*	2
Medicago scutellata	3	*Trifolium incarnatum*	2
Medicago truncatula	2	*Trifolium balansae*	3
Trifolium hirtum	2	*Ornithopus sativus*	3
Trifolium resupinatum	2	*Ornithopus compressus*	3
Trifolium subterraneum	5	*Biserrula pelenicus*	2
Dactylis glomerata	3	*Lolium multiflorum*	10
Lolium perenne	7		
Total Seeds	30		30

Tab. 3 – Covering, with species adapted to clay, neutral or acid pH soils.

7) The good productivity and turnover of olive groves requires an excellent development of olive trees in the early years. The partial elimination of the herbs along the line may contribute to this objective (Figs. 4 and 5);

Fig. 4 - Mobilization along the line - one side is not yet done yet. The sandwich method was applied for organic apple orchards, but here applied to a new olive grove in Alentejo, Portugal (Serpa, Portugal, 2009)

Fig. 5 – Disc-harrow machine in transport position, performed at the farm for mobilization along the line by the sandwich method (Serpa, Portugal, 2009)

8) For the olive groves in full production, total covering will be the best solution. Maintenance will be made by periodic cuts between spring and early summer, with a hammer-type blades machine (Fig. 6) or vertical axis mulchers with chains or blades.

Fig. 6 - Cutting the grassing (seeded + spontaneous), and triturating of foliage pruning, with decentered hammer-type blades machine, in a mature olive grove in the Alentejo, Portugal (Serpa, Portugal, 2011)

Soil conservation should always be present in all agricultural practices applied in the olive grove and in particular in sloped lands, as are most of the olive groves in Portugal and in the World. The largest part of the authors who have studied the soil erosion issue agree on the best solution to this problem. The main propose is to cover the soil with herbaceous vegetation. This cover has three functions:

1) To reduce the number and intensity of the impacts of water drops of rain on the soil;

2) Increase the speed of water infiltration into the ground;

3) To fix carbon in the soil through photosynthesis and the subsequent formation of humus or stable organic matter.

Tab. 4 shows the results of an experiment made with a rainfall simulator in three types of soil covering in an olive grove where the only practice preventing erosion is the covering with herbaceous sown in early autumn.

Tab. 4 - Three soil management systems under test with rainfall simulator for 15 minutes and measurement of superficial overflow and soil loss by water erosion (adapted from Pastor Muñoz-Cobo, 1994).

Soil covering	Superficial overflow (l/m^2)	Loss of soil by erosion (g/m^2)
Green manure barley based (*Hordeum vulgare*) sowed in autumn	3	10
No mobilization and total herbicide	25	485
Total mobilization without herbicide	24	1300

2.2. Fertilization

Soil covering and green manuring, previous mentioned, are also fertilization techniques. If they are not good enough to fertilize the olive grove, one can still turn to the following:

1) The application of organic wastes on soil as fertilizers, like solid olive mill waste (SOMW) and olive oil mill waste water (OOMWW) from the mill must be considered the priority technique.

2) Additionally, authorized correctives and organic/mineral fertilizers, although not from organic production, can be used.

The SOMW can be of three types - virgin from three phases press, virgin from two phases mill and from discontinuous (traditional) press-type mill. The first and third have commercial value, whether for oil extraction, whether for use as fuel after withdrawal of the oil. The two-phase SOMW has more water (OOMWW) and therefore represents a cost, not an income (Fig. 7).

Fig. 7 – SOMW from two a two phases mill, and olive leaves from the cleaning process (background in the photo) and tannery waste, stored in a plastic waterproofed manure for composting (Torre de Moncorvo, Portugal, 2004)

The two phase olive SOMW can be employed in composting, later on used as organic corrective and nutrients supplier (Fig. 8, Tab. 5).

Fig. 8 - Composting of SOMW, grape stalk and tannery waste to fertilize an olive grove in a demonstration project at Vale da Vilariça, Portugal (Torre de Moncorvo, Portugal, 2007)

Tab. 5 - Composition of compost made from two phases press SOMW (64%), grape stalk (33%) and olive leaf (3%)

Fertilizer	Humidity (%)	Organic Matter (%) odm (1)	N-total (%) odm[1]	$N\text{-}NH_4^+$ (mg/Kg) odm[1]	C/N	pH	Electrical conductivity. (dm/cm)
Compost	26,27	53,70	1,04	26,50	25,8	7,46	0,77

Notes: [1] odm: over dry matter

The compost mentioned in Tab. 5 has a high content of organic matter and a very substantial amount of nitrogen. An application of 10 t/ha gives about 100 kg/ha of nitrogen to the olive grove, and a significant portion of it would be available within two years.

To achieve more uniform compost in a shorter period is necessary to revolve frequently, which will be facilitated by appropriate equipment (Fig. 9). More important than this is the addition of a structuring agent to the wet SOMW, in order to compensate the lack of porosity of SOMW (Cegarra *et al.*, 2004). The ability to join different materials is the support of a successful composting process. Without this skill we risk making silage instead composting.

Fig. 9 - Equipment for turning and aerating compost (Torre de Moncorvo, Portugal, 2004)

With the addition of more nitrogen organic waste, such as tannery waste (waste of tannery without chromium), is possible to obtain compost with higher content of nitrogen, up to about 3% odm. Above this value, the organic corrective can be classified as fertilizer.

The compost pile should be covered with a suitable geotextile blanket, which allows air entrance, but not water and protects the top layer from the sunlight (Fig. 10).

Fig. 10 - Geotextile blanket on the compost pile for protection against rain and sun (Torre de Moncorvo, Portugal, 2007)

This avoids the leaching of nutrients and organic matter and the consequent pollution of aquifers and/or water lines, as well as the fertilizer impoverishment. It also prevents drying and destruction of millions useful microorganisms that lay in the compost. After several months of composting process, quality compost can be achieved (Fig. 11).

Fig. 11 - Compost mostly made from olive SOMW and grape stalk ready to be applied in the olive grove (Torre de Moncorvo, Portugal, 2007)

According the place to be applied, OOMWW from the three phases presses (both rare and traditional ones, and continuous) may be considered as a polluting product or as a fertilizer. In a water line, the OOMWW organic compounds cause a lack of oxygen in water and subsequent death of fishes and other aquatic animals. In agricultural soils this amount of organic substances can be consider as a fertilizer, if certain levels are not exceed. The high level of organic matter, potassium, nitrogen and phosphorus, in the OOMWW make this waste an inexpensive source of these nutrients (Garcia-Ortiz, A. *et al.*, 1995). In the year 160 b.C. Marcus Porcius Cato, in his book "*De agricultura*," recognized the fertilization value of OOMWW! Portuguese agricultural offices only recently found out all this value, after having closed many mills because they have no solution for this waste, although many tests were already made in other countries, mainly in Italy, where the law 574/96 has allowed its application to the soil (Tamburino *et al.*, 1999).

The composition of the two types of OOMWW is shown in Tab. 6.

Tab. 6 - Organic matter and macronutrients from two types of OOMWW in olive oil presses (Fernandes, 1995)

Parameter	Pressing mill	Three phases continuous press
Organic matter (%)	10,5	2,60
Nitrogen (%)	0,20	0,06
Phosphorus (%)	0,05	0,01
Potassium (%)	0,36	0,12
Magnesium (%)	0,02	0,004
pH	4,5-5,0	4,7-5,2

In Portugal only in 2000 official permission was given to apply OOMWW in the soil as fertilizer (*Despacho conjunto dos Ministérios da Agricultura e do Ambiente, nº 626/2000*). Nowadays, to apply OOMWW to the soil, which is preferably done between March and November, producers must request and pay an annual license to the regional Environmental Services, have a reservoir for temporary storage, correct the pH, preferably applied between March and November, use it only in trees and shrubs and respect the maximum annual limit of 80m^3/ha.

With this dose, about 8,4 t/ha/year are applied (hydraulical press) or 2 t/ha/year (continuous extraction method). This last value must be increased, as Italian researchers propose to Italy, where the maximum portions vary from 50m^3/ha/year in the discontinuous extraction method to 80 m^3/ha/year in the continuous system (Tamburino *et al*., 1999).

Branches pruning (with diameter less than 40 mm) are another value residue that must return to the soil, instead of being burned. These branches must be crushed with a hammer-type blades machine and left unburied on the ground. Apart from organic matter that slowly mixes with the soil, producing humus, nutrients are also released to the soil. For each ton of branches with 50% moisture, 4kg of nitrogen, 0,5 kg of phosphorus, 4kg of potassium, 5kg of calcium and 1kg of magnesium are released

(Amirante *et al.*, 2002). This way, the CO^2 and other greenhouse gases productions are reduced, since the amount of organic matter and carbon is very high. It is estimated that for each 100kg of harvested olive fruits, 65 kg of stems and leaves and 15Kg of wood (over 40mm in diameter) are produced.
The crunch of pruning branches can also be used to fight the olive bark beetle *(Phloeotribus scarabaeoides)* as indicated on subchapter 2.3.

When the application of these wastes as fertilizers is not enough to fulfill the culture's nutrient needs, we must undertake an additional fertilization. Among the macro nutrients, nitrogen and potassium are the most needed for olives trees. The annual organic exportations are also dependent from olive fruits production. With productions around of 3,5t/ha, nutritional requirements are as shown in Tab. 7.

Tab. 7 - Olive tree NPK nutritional requirements for a yield of 3.5 t/ha (Warlop, F. 2002)

Yield (t/ha)	Nitrogen – N (Kg/ha)	Phosphorus – P (Kg/ha)	Potassium – K (Kg/ha)
3,5	100	50	150-200

Note: NPK – Nitrogen; Phosphorus; Potassium

2.3. Plants Phytosanitary Protection

To protect olive grove from plagues and diseases, we must start by cultural prevent measures. Ecological infrastructures to increase beneficial organisms, which contribute to plague natural limitation, are also initial measures to protect against plagues and diseases.

Main plagues are olive fruit fly (*Bactrocera oleae*), olive moth (*Prays oleae*), jasmin moth (*Margaronia unionalis*) and black-scale (*Saissetia oleae*). Occasionally, tabby knot-horn (*Euzophera pinguis*), olive psyllid (*Euphyllura olivine*), olive bark beetle (*Phloetribus scarabaeoid*) also can be found and cause damage.

Main diseases in olive trees are olive anthracnose (*Gloeosporium olivarum*), peacock spot (*Spilocaea oleagina*) and olive knot (*Pseudomonas savastanoi*). Most recently problems with verticillium wilt (*Verticillium dahliae*) have been noticed in new groves, causing death to all trees.

Pruning is a major agronomic technique where ill, inside and shadowed branches are removed. This method prevents some plagues, especially black scale, which preferably attacks these kinds of branches. The crushing of the pruning branches can also be useful for fighting the olive bark beetle. This can be achieved by leaving the foliage on the ground long enough for females to do their egg-laying with subsequent foliage and larvae crushing.

Another practice is avoid harvest with long wooden sticks, due to wounds inflicted by the sticks. These ones, besides breaking the future productive branches also carry diseases such as tuberculosis that flows easily into the wounds. As a desirable alternative to the wooden sticks harvest method, collect by vibration or by manual or mechanical collection should be done.

Also, the balanced fertilization, without excess of nitrogen, is essential to reduce the pest attacks from sucking and chewing insects like black-scale and olive psyllid.

The natural limitation of plagues, resulting from the action of the beneficial organisms, is very important to reduce populations of these plagues and also because it can reduce economic losses. Often this action is sufficient and does not require the application of pesticides. The olive grove has a rich and diverse set of beneficial organisms, which contributes decisively to reduce the damage caused by plagues and to prevent the new plagues development, through the regulation of their populations (Gonçalves *et al*., 2004). Among the olive grove beneficial organisms, entomophagous insects are the most relevant (Fig. 12). Although, recent studies focus the role of other arthropods like spiders, and also, even if with scare information about its behavior, birds and small mammals (Torres, 2006).

Fig. 12 - Coccinellides (*Coccinela septempunctata*) in a leaf of an organic olive tree (Serpa, Portugal, 2008)

Ecological infrastructures foundations are essential to facilitate beneficial organism's activities, since this provides them food and/or shelter. Main ecological infrastructures to implement are: soil cover between trees rows, limiting hedges on olive groves, and/or maintenance of natural vegetation on adjacent fields. Some of the most favorable plants for beneficial insects (coccinellids, chrysopids, hoverflies and hymenopterous parasitoids), are the umbelliferas (apiacea). Among these, bitter bennel (*Foenicum vulgare ssp. piperitum*) and wild sea carrot (*Daucus carota ssp. maritimus*) are the most relevant. It has been noticed that a covered soil has greater abundance and diversity of beneficial organisms when compared with uncovered olive groves, where herbicide application or soil mobilization are common techniques (Torres, 2006).

The main beneficial predator's insects are:

- Green lacewing (*Chrysoperla carnea*), which can destroy more than 90% of the olive moths eggs, besides eating other insects such as black-scale and olive psyllid (Fig. 13);
- Flower bug (*Anthocoris nemoralis*), which fights the olive moth, olive psyllid and olive thrips;
- Coccinellid species like *Chilocorus bipustulatus* are important black-scale predators;
- Flower fly from *Xanthandrus comtus* specie that fights the olive moth and olive psyllid.

Besides insects, spiders and mites, some insectivorous birds like warbler (*Sylvia melanocephala*) are also relevant. These birds combat olive moth, psyllid, black-scale and olive fruit fly.

Fig. 13 - Grouped green lacewing eggs on olive fruit, from where larvae will be born with predator activity over the olive trees plagues

Sometimes, cultural and natural limitation measures are not enough, so the plagues with the most negative economic impact should be monitored and, if necessary, fought. Risk estimation can be calculated by direct observation of the damage organs or by capture traps. Observed values are compared with Economic Level of Attack (ELA) and when this level is overtaking, protection measures are applied. For Portugal, ELA is set by "Direcção Regional de Agricultura e Desenvolvimento Rural" (Felix *et al*., 2008) and this level is the same as for Integrated Protection (IP). However, in some cases, the experience of organic olive grove production in Portugal does not confirm the possibility of adopting OF parameters, already tested in IP. This takes place namely in situations where the authorized phytopharmaceuticals product (PP) have lower efficiency than others, authorized in IP. This is the case of *Bacillus thuringiensis* (Bt), which in olive moth fruit generation (*carpophagus*) has no efficacy. Therefore, there is no need of ELA in this generation.

<u>Olive moth (*Prays oleae*)</u>

Risk estimation and ELA in the flower generation (*anthophagus* generation)

Method A - delta traps with sexual pheromone:

- Traps to at least 50m away from each other and placed at the height from 1,50 to 2 meters, inside the canopy, in March.
- Weekly count of captured males: ELA=15 catch/day/trap.

Method B - Visual observation of 100 flowers bunches

- Weekly counting of attacked floral brunches: ELA=10% (5% if the production is overvalued)

Treatment: *Bacillus thuringiensis*

- Dose: 0,4 to 0,6 kg/ha;
- Effectiveness: around 60% of mortality.

In new olive groves it can be also appropriate to attack leaf generation (*Phyllophagous* generation), as the destruction of the leaves can seriously damage the tree. In this case, visual observation is the appropriated procedure and ELA is 10% of terminal attacked buds.

<u>Jasmin moth (*Margaronia unionalis = Palpita unionalis = Palpita vitrealis*)</u>

With about 30mm of wingspan, this white semi-transparent insect shows, on his larval phase, green caterpillars, which reach 25mm long in their final growth stage. Although the last cause damage to leaves and fruits, their economic impact on adult trees is not significant (Torres, 2007). In nurseries and young olive groves, this caterpillar may cause damage and therefore ELA must be applied.

Risk estimation and ELA:

- Delta or funnel traps with sexual pheromone to capturing adult males. Main proposal is detection since there is no defined ELA.
- Visual observation of attacked plants: ELA=5%.

Treatment: *Bacillus thuringiensis* (same as for olive moth).

Olive fly (*Bactrocera oleae*)

In regions with more temperate climate, closer to the sea, the olive fly is the main olive grove plague. Economic income is reduced because of the decrease on yields and olive oil quality. In inland areas, hot summers and cold winters are against insect development. For instance, last summer, all eggs were destroyed under temperatures exceeding 40°C, for several days.

Risk estimation and ELA:

- Chromotropic traps with sexual pheromone (Fig. 14). Traps with and without sexual pheromone must be over 50m apart, placed in March (littoral) and April (inland). A high level of captured males on yellow sexual pheromone traps means sexual activity.
- ELA for mass capture: 21flies/trap/week (3/day).

Fig. 14 - Chromotropic and sexual trap to risk estimation of olive fly

Treatment A: massive capture with food traps.

Most common traps are “flying bottles” with diammonium phosphate (DAP) 5% (50 g/liter/trap), with 50 to 100 traps/ha density, depending on the intensity of the attack. These traps are placed in early summer, on south or southeast side, inside the tree crown, in the shadow and at eyes level. When there is evaporation, attractive product must be replaced (Fig. 15).

Fig. 15 – Plastic "flying bottles" type OLIPE ("Olivarera los Pedroches") with diammonium phosphate and water, to olive fly massive capture.

Treatment B - Partial spraying with spinosad and bait food

Although recently authorized in organic farming, this treatment must be used only in extreme conditions, since spinosad is toxic to some beneficial insects. As mentioned above these insects are important to fight main olive grove plagues.

<u>Black scale (*Saissetia oleae*)</u>

The black scale is a sucking and chewing insect that weakens the tree and produces sweet, sticky, 'honeydew'. This is an important food source for sooty mold, a saprophytic fungus that also jeopardizes the olive tree by covering leaves and therefore reducing photosynthesis.

The most important agronomic procedures to minimize black scale attacks are:

- Pruning most concentrated and shadow tree branches;
- Fertilization with a non excessive nitrogen level.

Phytosanitary treatment

As agronomic measures are not enough, a phytosanitary treatment must be applied, like summer oil or paraffin oil (less phytotoxic) according to the following conditions:

- 1,6 liters/100liters, with high pressure spray over the first-instar larvae, the most sensitive ones (June-July);
- Do not treat if there are hydric deficit.

Generally, most of the other olive grove plagues do not need phytosanitary treatment. The plague that occasionally occurs with severity is Euzophera, being the third most dangerous one in Spain. In organic farming there are no approved and authorized insecticides for a direct intervention. "Sexual confusion" method has been tested in Portugal (Trás-os-Montes) and Spain, with good results, and might be a feasible and economical solution in the short term.

Olive grove diseases, caused by fungi and bacteria, causes huge losses when phytosanitary treatments are not performed, mainly in the warmer climate regions.

Olive anthracnose (*Gloeosporium olivarum*)

In the case of a new olive grove, in a region with favorable climatic conditions to this disease, more resistant and suitable cultivars must be chosen:

- "Azeiteira", "Blanqueta", "Carrasquenha", "Cobrançosa", "Negrinha (de Freixo)", "Picual" (Espanha), "Verdeal de Serpa" and "Verdeal-transmontana".

In olive groves already installed, with sensitive cultivars, such as "Galega", risk estimative and adequate treatments should be made in order to avoid the disease.

Weather conditions (record and measurement):

- Occasional precipitation: allows primary infection; continued precipitation: allows secondary infection and make the attack more severe.
- Temperature (average, minimum and maximum), 10-30°C: possible infection; 20-26°C: optimal temperature (at 23°C visible symptoms in 2 to 3 days)

Visual observation (first injury on the fruit)

ELA:

- Apply treatments whenever favorable weather conditions occur and sensitive cultivars are used. Also, when any symptoms are observed in the olive fruit;
- Critical Period: September/October, at early rains.

Main agronomic measures:

- More resistant and adapted cultivars;
- Frequent pruning, allowing an airy canopy (but without removing the whole interior);
- Avoid nitrogen excess;
- Large distance between olive trees, avoiding contact between canopies and shading.

Phytosanitary treatment:

- Copper fungicides: with a maximum of 6 kg/ha/year of elemental copper Cu (=30 kg of commercial formulations of Bordeaux mixture): copper sulphate with slaked lime (Bordeaux mixture), copper oxychloride, preferably with "adhesive wetting", copper hydroxide and cuprous oxide.
- Fertilizers with copper complexes: copper gluconates, copper formulations which are not considered for the copper annual maximum limit. This set aside is justified because they are absorbed, have few nutrients and therefore are classified as fertilizers, not requiring approval.

<u>Olho-de-pavão (*Spilocaea oleagina*)</u>

In some regions and for some cultivars this disease can be more dangerous than olive anthracnose, since it can cause a severe drop of the olive leaf with consequent loss of production. Attack with more intensity in the late winter and early spring, if weather conditions are favorable:

- Occasional precipitation: allows primary infection;
- Continuous precipitation: allows secondary infection and worsens the attack;
- Time-leaf wetness: greater than or equal to 14 hours: allows infection;
- Temperature (average, minimum and maximum), 8-24°C: possible infection; 15ºC: optimal temperature (visible symptoms in two weeks).

Main agronomic prevention measures are as follow:

- More resistant and adapted cultivars, as "Cobrançosa";

- Frequent pruning, allowing an airy canopy (but without removing the whole interior);
- Avoid nitrogen excess;
- Large distance between olive trees, avoiding contact between canopies and shading.

How to estimate risk:

- Visual observation of leaves: 20 olive trees x 5 buds x 2 leaves = 200 leaves;
- Early detection of the first stains: soak in NaOH 5% aqueous solution for 30 minutes.

The treatment is done as soon as weather conditions are favorable, or as soon as the first circular leaves stains are detected, preferably using a sodium hydroxide aqueous solution. Copper fungicides used for olive anthracnose are also applied in this case.

<u>Olive knot (*Pseudomonas savastanoi*)</u>

This bacterium goes into the tree by wounds and spreads through branches and trees by contact, particularly when a long stick to collect olive fruits is used.

The best preventive measure is to harvest with a portable generator with a T-shape rod or a mechanical vibrator.

Some varieties like "Cordovil" are much more sensitive than others, like "Cobarançosa" and "Verdeal". Therefore, this is an important issue in new olive groves as well as the observation of the young trees in the nursery in order to detect any eventual symptom.

When harvest is made using long sticks or when the disease is already present in the grove, copper fungicides provide some protection but are not sufficient.

<u>Verticillium wilt (*Verticillium dahliae*)</u>

This is a recent growing up disease, causing weakening and death of some olive trees in new groves. In case of a severe attack and when the fungus presence is confirmed, the olive grove must be uprooted.

One possible mean of attack is soil solarization, which means watering the soil in early summer and covering it with polyethylene films around the ill trees. As the fungus is very hot sensitive, just a month and half of solarization is enough to eliminate it.

2.4. Harvest and transport of olive fruits

At harvest and transport some important goals must be achieved:

- Do not break productive next year branches;
- Do not make wounds in branches which can be gateways to olive knot;
- Do not hurt the olive fruits, since these and olive oil quality depends upon healthy fruits.
- Harvest the olives fruits in a good state of maturation, neither too green nor too ripe;
- Transport conditions must avoid the olives fruits crushing and fermentation.

To achieve these objectives harvest cannot be made with long wooden sticks, which is the traditional practice of olive fruits harvesting. Alternatively, the following practices can be considered:

- Manual harvesting in small olive groves.
- Mechanical harvesting with electric (battery) or fuel hand olive harvester, in medium-sized olive groves and cultivars where fruits do not fall down by vibration.
- Branches vibration with fuel vibrator, medium-sized olive groves, when the above technique is not possible or tree vibrator is not advisable (old trees or bad access for tractors)
- Trunk vibration with vibrator attached to a tractor or to a self-powered machine, for large groves.

Harvest should be followed by immediate transportation to the olive mill in order to produce the olive oil in the same day or in the next day. In transportation, open rigid boxes must be used, instead of closed bags or bulk transport with a very high quantity of fruits.

At the olive mill, leaves must be removed and the fruits cleaned. The olive oil production should start within 24 hours after harvesting.

Prolonged storage of olive fruits causes fermentation. This leads to breaking the links between fatty acids and glycerol from fat, leading to the increase of free fatty acids, i.e., acidity. Other flavor and smell defects can also be found (fusty, winey, mold), which are easily detected in a tasting prove, causing the immediate disqualification in any olive oil contest.

In what concerns to the harvest season, a good maturity occurs when later fruits have purple color and the others are already black. If consumers valorize bitter taste, harvest can be done earlier, when less mature olive fruits are in the transition from green to violet color.

Olive fruits should also be harvested to prevent further oxidation and eventual olive anthracnose when olives fly attack occurs. In olive fruits attacked only with olive fly is still possible to obtain olive oil with less than 1% acidity (Guillén *et al*., 1992). With olive fruits attacked by olive anthracnose this is no longer possible, since these fruits will greatly decrease the quality of the olive oil. The extraction process should be separated in this case, as well as for the olives on the ground which will still be used.

To ensure a good sanitary quality, pesticide preventative treatment with copper should be done on early rain falls. This procedure assures fruits protection from infections caused by fungi spore germination, in particular olive anthracnose (Fig. 16).

Fig. 16- Olive fruits in good sanitary conditions, treated with copper fungicide for protection against major diseases (olive anthracnose, peacock spot, Cercospora leaf spot, olive knot).

3. Organic olive oil production

3.1. Production techniques

Virgin olive oil production does not use chemical solvents. The product is obtained using only physical processes, which assurances greater quality. To obtain a product with maximum quality, fruits must be in good sanitary conditions. Besides that, inside the fruit, oil must maintain its own characteristics, avoiding oxidation processes or volatile compounds losses. This can be achieved with some caution during the successive phases of the technical procedures at the olive mill.

The first phase after washing olives fruits is the grinding process, where one must avoid a thin crush (emulsions can occur which reduces olive oil's yield and extraction) or a too long one (paste exposure to air may cause oxidation). But if the crush is too thick, cell walls rupture is insufficient, which also decreases olive oil yield.

After grinding, the malaxing is an important operation since it allows the merge of olive oil droplets into larger ones. This way, these larger drops can be easily separated from the solid olive oil waste and from the water olive oil mill waste water. The length of the malaxing process depends on the oil separation system that follows.

A malaxing period between 25 to 35 minutes is necessary in the pressing olive oil extraction process. For continuous centrifugation systems, 40 to 60 minutes are needed. Temperature must be adequate (25-30ºC) to avoid losses on volatile compounds, responsible for good olive oil flavors. The speed of electric mixer must be 14 to 18 rpm.

Olive oil extraction can be of various types, according the possibilities of the mill to separate solid and liquid phases. The pressing system, more classical, as well as the three phases continuous system separates olive oil, dry SOMW and OOMWW. The modern two phase continuous systems separates olive oil and wet SOMW (with incorporated OOMWW). Percolation systems (*sinolea*) are another system, less used because can only extract part of the olive oil. In all these extraction systems one can obtain a good quality olive oil, but with some differences between them.

In the continuous three phase's system, after malaxing, water must be added to the paste in order to facilitate the separation in two phases (by centrifugation). This method leads to loss some olive oil constituents, particularly chromatic and phenolic compounds. In two phase's continuous system, water is not added to the paste, thus olive oil is richer in antioxidants.

The percolation extraction or selective filtering is performed at olive mill's local temperature, without water addition. This way, olive oil maintains all its natural characteristics and a high phenolic level (Fragoso *et al*., 2006).

3.2. Packaging, storage, preservation and transportation

After the production process, olive oil must be quickly stored, avoiding air contact (oxidation) and light (photo-oxidation), in inert materials containers (e.g. stainless steel), highs and narrows, to reduce the air contact area. The suitable temperature is 15ºC, which allows a good sedimentation of olive oil impurities, without oxidation. Transportation or racking must be avoided, since they allow air entrance and inherent olive oil oxidation. A higher and conic container facilitates the removal of the sludge residues and prevents racking. Olive oil oxidation causes a rancid smell and taste rancid, which is a huge defect of the oil.

Olive oil quality, namely its non tendency to oxidize also depends on olives fruit cultivar. Main olive oil antioxidants are the tocopherols (vitamin E) and polyphenols, whose content varies with olives fruits cultivars. The UV absorbance at 270nm (K_{270}) is an index that measures the olive oil oxidation and must be held below 0,20. The finest and better quality olive oils, with a more balanced composition, can achieve rates below 0,10. The absorbance index of at 225nm also gives an indication of a bitter taste in olive oil (higher values mean more bitter taste).

Tab. 8 highlights these characteristics to the main cultivars in different Mediterranean countries.

Tab. 8 - Antioxidant compounds and absorbance ratios in olive oils from different cultivars, representing different countries (adapted from Guillén et al.., 1992)

Country	Cultivar	Maturation index	Tocopherols (vit. E)	Polyphenols	K_{270}	K_{225}
Spain	"Picual"	2,80	322	790	0,19	0,31
	"Arbequina"	1,84	237	195	0,10	0,16
Greece	"Coronoeiki"	1,16	321	637	0,20	0,54
Italy	"Frantoio"	2,18	253	359	0,11	0,28
Morocco	"Picholine marocaine"	2,94	260	791	0,21	0,30
Portugal	"Negrinha"(1)	2,76	258	381	0,11	0,44
Tunisia and Algeria	"Chetoui"	1,28	510	1347	0,23	0,95

(1) Although "Negrinha" or "Negrinha-de-Freixo", is not the main Portuguese cultivar, is one of the few with double use (canned and olive oil) with good quality for both purposes. One of the best Portuguese organic olive oil, awarded in international competitions like PremioBiol in Italy, is made from this cultivar, among others.

Based on these data (Tab. 8) we can evaluate some olive oil taste characteristics and its stability during storage. For example, the “Arbequina” cultivar, from Catalonia (currently the most widely grown in intensive olive groves) produces an olive oil of excellent quality (low K_{270}) with a smoothie taste (low K_{225}). However, the low percentage of tocopherols and polyphenols decreases the stability and conservation capacity. This kind of olive oil must be consumed in an early stage or mixed with another one, more stable. The “Negrinha” cultivar from Trás-os-Montes (NE Portugal) produces a fine and aromatic olive oil. However, even with not too high tocopherols and polyphenols levels, has an acceptable stability. The low value of K_{270} confirms that this is an olive oil of superior quality, although a little bitter, as seems to indicate its somehow high level of K_{225}.

It is also necessary to prevent entry of contaminants during handling. The plastic tubes should be avoided because these release phthalates in olive oil, which can be detected by analysis. Phthalates are synthetic chemicals substances that disrupt hormonal systems effects, so their presence is undesirable in foods. Plastic packaging for storage and packaging should be avoided for the same reason and, in the case of transparent plastic, to avoid photo-oxidation. In transparent polyethylene, olive oil oxidizes rapidly with increasing of peroxide index and reaches the maximum legal level in only 9-20 days. If one use the same material, but in shadow conditions, that index is reached in 120-190 days.

The final package should be dark glass, as this is an inert material that holds the olive oil in good conditions for more than a year. Stainless metals can also be used.

3.3. Labeling

Besides general information, common to all kinds of olive oils, the organic olive oil labeling must indicate specific information about organic production.
An organic quality olive oil must be "extra-virgin", which means is extracted only by physical processes (virgin) and with the following analytical characteristics:

- Acidity ≤ 0.8%;
- Peroxide index (oxidation) ≤ 20 meq O_2/kg olive oil;
- Absorbance at 270nm ≤ 0.20;
- Sensory analysis: median of fruity attribute>0, median of the defects=0.

Beyond these characteristics, common to other olive oils, an organic olive oil must also not contain residues from chemically synthesized pesticides, forbidden on organic farming. Therefore, those analyses must be done before the certification of the final product. In conventional or integrated production olive groves, if near to organic olive groves, the application of some pesticides, especially insecticides against olive fly, may lead to an accidental contamination. Thus, organic olive oil may have undesirable and forbidden residues. This risk increases when the size of olive grove is small or is opposite to the prevailing winds in times of phytosanitary treatments. The presence of other possible contaminants, such as phthalates, should also be avoided.

Specific indications to the organic production and certification, according to EU legislation, are the following:

- Council Regulation (EC) Nº 834/2007 - Title IV - Labeling (general issues);
- Commission Regulation (EC) Nº 889/2008, Title III - Labeling (EU Logo);
- Commission Regulation (EC) Nº 271/2010, (New EU logo).

1) Information concerning organic farming (in brackets, the Mediterranean olive oil producers who adopted the following terminology):

"Organic product", "product from organic farming," or "product from organic agriculture" (Portugal, France, Italy, Greece), or;

"Ecological product", or "product from ecological agriculture" (Spain), or;

"Bio" and "eco" abbreviation can also be used in labeling.

2) Information regarding certification:

The control and certification body must be indicated on the label, using the code assigned by competent authority of the country where the product was produced, packaged and labeled.

Example: PT-BIO-01 (PT-Portugal; BIO-Organic Farming, 01- order number assigned to the control and certification body).

3) EU organic farming logo

To help consumers to identify an organic product, the European Commission adopted a new logo for pre-packed products with at least 95% of organic ingredients. This is also applicable to olive oil, because, although transformed from the olive fruit, is 100% olive oil. Regulation (EC) Nº 271/2010 defines this logo, its characteristics and conditions of use, which became mandatory (the previous logo was optional) from July 1, 2010.

4) National or private logos

In addition to the Community logo, nationals (if they exist, as in France), privates, associations or companies' logos can also be used.

5) Origin of ingredients

It's mandatory to indicate on the label the geographical origin of the ingredients that means if they are produced in the European Union or elsewhere. The name of the country is optional. In the case of an EU product, it must be indicated "EU Agriculture" (or "EU country").

6) Products in conversion

In the case of olive oil from groves in conversion (2^{nd} and 3^{rd} years), it can be indicated in the label "product under conversion to organic farming", giving the code number of the control and certification body. However, is forbidden to use the EU organic logo.

To illustrate the packaging and labeling, Fig. 17 shows a bottle of organic olive oil in dark glass (to avoid photo-oxidation) with the former logo.

Fig. 17 - Organic olive oil label with former logo, in a dark glass bottle

In Fig. 18 one can see the new logo (in this case one color version) in stainless container and opaque to light

Fig. 18 – Organic olive oil label with the new logo, one color version, in stainless container.

In both cases it is an olive oil produced in Serpa (Alentejo, Portugal), based on Portuguese cultivars, classified in November 2010 by an Italian jury as the best organic olive oil of the year, among the many others who were examined, from 42 countries (Oreggia , 2010).

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5. Glossary

Organic Farming: according to EU legislation (Council Regulation (EC) Nº 834/2007), also known as ecological agriculture and organic agriculture across the Member States.

Conventional production: non-organic or integrated production, which uses chemical synthesis fertilizers and pesticides.

Control and certification body – Organization approved by the competent authority of the country where it operates and accredited/audited by the national official accreditation.

Integrated production: production with limitation values for the use of chemical synthesis pesticides (positive lists) and with some restrictions on the fertilizers doses allowed.

6. SELF-ASSESSMENT

1. The EU legislation for organic farming is the same for all Member States and includes the following:

a) Principles and practices of organic production of olive fruits and olive oil, but exclude the control and certification rules;

b) Principles and practices of organic farming where it fits the production of olive fruits and olive oil, and also the rules of inspection and certification;

c) General principles of organic production and inspection and certification rules, but in what concerns to production techniques and phytosanitary protection, national legislation prevails (as occurs in integrated production).

R: b)

2. For a stricter and credible certification, the certification and control body must do the following:

a) Make an annual schedule inspection and an additional unannounced visit only in case of suspicion;

b) Always do analysis instead of the not advised control visit.

c) Always make both types of control visit, complemented with at least one pesticide residue analysis;

R: c)

3. For the planting of an organic olive grove, what kind of density/plant spacing should be followed in order to comply with the principles of organic farming, particularly on disease prevention?

a) Semi-intensive olive groves with densities of about 300 trees/ha;

b) Only the traditional and more extensive plant spacing, with about 100 olive trees/ha;

c) More intensive olive groves with 500 trees/ha or more;

R: a)

4. To avoid soil erosion, a serious problem in all olive production regions, what are the best agronomic practices compatible with organic production?

a) Do not mobilize the soil and apply an organic herbicide;

b) Do not mobilize the soil, cutting and grinding plants and pruned branches, leaving it on soil (mulching);

c) Mobilize the soil between rows.

R: b)

5. Green manure can be done in the olive grove, but only under certain conditions. Which ones?

a) Always in new olive groves;

b) In new olive groves, where the erosion risk is low;

c) Always, unless an intercropping between grasses and leguminous species are made.

R: b)

6. Which mill byproducts can be applied as organic fertilizers in the olive grove?

a) All (SOMW, OOMWW, olive leaves), preferably after composting;

b) Only OOMWW, and to the maximum annual dose of 80m^3/ha;

c) Only the SOMW and olive leaves.

R: a)

7. In the phytosanitary protection of the olive grove, which of the beneficial insects mentioned below are important to fight the plagues?

a) Phytoseiid mite, fighting the red spiders mite;

b) Seven-spot coccinellides (*Coccinela* septempunctata) to combat black scale;

c) Green lacewing (*Chrysoperla carnea*) to fight against the olive moth.

R: c)

8. The olive fly can be fought in organic agriculture. What is the most widely used method, which has proven to be effective?

a) Spraying with spinosad insecticide;

b) Yellow chromotropic traps;

c) Massive capture with food traps, type OLIPE bottle.

R: c)

9. To combat the major diseases of olive trees, in addition to cultural practices such as pruning, which pesticides are most effective?

a) Sulphur;

b) Copper fungicides;

c) Potassium permanganate.

R: b)

10. To obtain a quality olive oil, the maximum time between harvest and production must be:

a) One week;

b) One day (24 hours);

c) Half a day (12h).

R: b)