ACHIEVEMENTS OF PROJECT CFC /IOOC/04
"*RECYCLING OF VEGETABLE WATER AND OLIVE POMACE ON AGRICULTURAL LAND*"

GOOD PRACTICE IN VEGETABLE WATER AND COMPOST SPREADING ON AGRICULTURAL LAND: CASE OF OLIVE GROWING

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Project CFC/IOOC/04 on the "*Recycling of vegetable water and olive pomace on agricultural land*" was set up by the Common Fund for Commodities (CFC) and the International Olive Council (IOC) for the benefit of four South and East Mediterranean olive growing countries: Algeria, Morocco, Tunisia and Syria.

The broad aim of the project was to transfer technology on the application of vegetable water (VW) and olive pomace on agricultural land and to highlight the advantages of these practices in raising crop yields and improving soil fertility as a feature of sustainable, environmentally friendly olive growing.

The project was modelled on the results of research conducted in Italy and Spain, which generated the field trials, technology and know-how that was later transferred to the countries concerned.

INTRODUCTION

Olives and olive oil are just a tiny part of the biomass produced throughout the "olive process". The remainder is made up of vegetable water (VW) and olive pomace. These two by-products are generated when the olives are crushed to make olive oil. Both, VW particularly, cause serious environmental problems (river and underground water pollution, etc.) in all the Mediterranean olive growing countries and their solution represents an environmental challenge upstream and downstream of the olive oil production chain.

In most olive growing countries, even in the most advanced ones, no definitive answer has been found for the disposal and treatment of this biomass. It is still a major environmental issue, especially in the South and East Mediterranean countries where vast planting and processing modernisation schemes are underway to expand and upgrade the quality of olive oil produced.

The olive pomace generated by the three-phase system does not pose problems because it can be treated to extract its residual oil or it can be used for fuel. However, VW disposal continues to be a serious problem in some olive growing countries.

The olive growing countries in the Mediterranean region have taken differing, one-off approaches to resolving the problem of VW. Some opted for storing the VW in evaporation ponds, but this was not successful because of the ensuing stench and infiltration problems and the poor management of the resultant dry waste. The application of VW as a fertilizer and organic amendment on agricultural land was then put forward as a rational way of recycling this liquid effluent, which is brownish–red to black in colour.

VW spreading is regulated under the national laws of certain olive growing countries such as Italy (1996). It must be put into practice with due regard for the environment, particularly to avoid all risk of river and ecosystem pollution. In such conditions, the application of controlled amounts of VW is an olive fertilization practice that is friendly to the environment and crop.

Extraction systems and olive by-products

Olive by-product extraction systems:

The makeup and characteristics of olive by-products (VW and olive pomace) depend heavily on whether the extraction system used is two-phase or three-phase.

The continuous three-phase system uses a lot of water, thus generating a large quantity of pollutant liquid waste (VW). By comparison, the two-phase system needs less water but generates more wet olive pomace, which is very difficult to manage (drying is essential). The two-phase system has not helped to resolve the pollution problem because of the heavy investment and higher costs involved in treating the wet olive pomace.

Olive by-products:

VW:

VW is the aqueous phase generated during olive oil extraction. It varies in quantity depending on the extraction system used.

Table 1: Extraction systems and quantity of VW produced

Extraction system	Quantity of VW (litres)
Pressing	From 450 to 650 litres/t olives
Three-phase centrifugation	From 850 to 1200 litres/t olives

Olive pomace:

Olive pomace is the major by-product of both two-phase and three-phase extraction.

Table 2: Chemical composition of olive pomace according to extraction system

Characteristics	Extraction system		
	Pressing	Three-phase centrifugation	Two-phase centrifugation
Water (l/t olives)	450–650	850–1200	80
Quantity (kg/t olives)	350	500	800
Moisture (%)	25–28	40–55	55–65
Oil (% wet matter)	6–8	4–5	3
Oil (% dry matter)	8–10	6–8	5–6
Reducing sugars (%)		2	5
Polyphenols (ppm)		10 000	23 000

VW and olive pomace contain a large amount of both organic and inorganic matter. Coupled with the ability of the soil to decompose and break down organic matter and the ability of plants to absorb nutrients from the soil for growth, this led to the application of these two byproducts to crop land.

This is the background to the interest in examining more closely good practices for spreading olive oil by-products on agricultural land.

What good practices should be followed for spreading VW on agricultural land?

Practice 1: Determination of VW characteristics before spreading

Determining the chemical characteristics of VW prior to spreading is an essential step to evaluate their composition and compare it with the optimal range of values recommended for VW application on crop land.

The most important parameters that have to be determined are reported in the next table:

Table 3: Optimal characteristics of VW composition for application to olive orchards

VW composition: optimal range of values		
Parameters	Continuous three-phase centrifugation	Discontinuous system
Dry matter (%)	5.8 – 6.1	6.8 – 9.4
Moisture (%)	93.9 – 94.2	91.6 – 93.2
pH	4.5 – 5.9	4.5 – 5.0
EC (mS/cm)	6 – 6,7	7.11 – 14.35
Mineral matter (%)	0.4 - 1.7	0.6 – 1.9
Organic matter (%)	7.3 – 9.2	9 - 16.5
Polyphenols (%)	0.15- 0.4	0.54 – 0.77
Total nitrogen (%)	0.1- 0.58	0.35 – 0.7
Potassium (%)	0.2 – 0.6	0.63 – 0.97
Chemical oxygen demand (g/l) (COD)	30 -70.2	50 - 110
Biological oxygen demand (g/l) (BOD)	10 – 60	20 – 100

VW intended for agricultural purposes must not be treated in any way before spreading; only water should have been added to dilute the olive mash during the extraction process.

Practice 2: Soil analysis before VW spreading

The physico–chemical structure of the soil and its biological activity determine soil fertility and are therefore fundamental elements in ensuring sustainable agricultural yields. Nitrogen, phosphorus, potash and organic matter are the most important soil fertility parameters along with the inorganic storage capacity of the soil, particularly its total exchange capacity, the status of the soil adsorbing complex and the saturation rate.

From a practical standpoint, the application of VW does not affect the chemical and biological quality of the soil when it is clayey and calcareous (basic pH). Similarly, VW can be spread on shallow (20 to 30 cm) finer textured soils, which have better water and fertilizer storage capacity.

Chemical analysis of the soil is strongly recommended before VW spreading to determine two parameters: pH (acidity) and electrical conductivity (salinity). This is intended to identify the values at which these parameters become toxic for the plants and to determine the biological activity of the soil when the limits are exceeded. Moreover, this practice allows the VW to be spread directly on agricultural land without any previous treatment.

Practice 3: VW collection for spreading

When the olive oil mill is on the farm, the VW can be collected straight from the decanters in mobile tanks and spread directly on the fields; otherwise, it can be collected in storage basins.

Photo 1: VW storage basins

Practice 4: Timing of VW spreading

The period recommended for spreading VW is from November to March. Generally, it is advisable to use the VW within the first 30 days of production and storage, when its quality is at its best.

This period coincides with the vegetative rest of the olive trees and slower activity of soil microbiological life. VW must not be spread on crops when they are at the height of their vegetative growth, nor must it be applied to crop foliage. Likewise, to prevent leaching, it must not be applied on days when there is rain or frost.

Practice 5: VW spreading technique and recommended application rates

VW is applied using a 4.5–5 ton spreader equipped with an adjustable flow rate to ensure even distribution on the soil.

For olive trees, the VW must be spread between the orchard rows at a distance of 0.5 to 1 m from the tree trunks. The recommended application rate for olive trees is 80 m^3/ha/year when the VW is from continuous three-phase systems, and 5–10 l/m^2 or 50–100 m^3/ha/year when it is from discontinuous systems.

Photo 2: VW spreading in olive orchards

Practice 6: Practices after VW spreading

Shallow ploughing (with a vibrating tine cultivator) is strongly recommended after spreading to make sure the nutrients in the VW are properly incorporated into the soil. Ploughing mainly helps to bind the clay–humus soil complex with the VW, thus preventing it from being dragged off by runoff or percolation, and also helps to avoid potential visual nuisances and/or unpleasant smells.

Photo 3: Ploughing with a vibrating tine cultivator

Recommendations for VW spreading on agricultural land

The application of VW to crop land is a simple, cheap and effective method of restoring soil nutrients and preventing environmental pollution. However, in certain cases, it is prohibited on:

1. Agricultural land with a neutral and/or acid pH and a very coarse texture (sandy and stony soils).
2. Hydromorphic soils at low points in the terrain or linked to the presence of wet areas.
3. Soils with shallow water-tables with a depth of less than 10 m.
4. Land very close (at a distance of less than 20 m) to a water source (well, lake, river, etc.).
5. Land with a gradient of more than 15% (risk of VW runoff).
6. Land that is flooded or waterlogged (in the case of rain).
7. Land close to urban areas.

What good practices should be followed for spreading olive pomace compost on agricultural land?

Practice 1: Determination of the characteristics of the olive pomace before and after composting

Olive pomace is made up largely of fruit matter (olive skins, flesh, seeds and stone fragments), plus a small amount of vegetation and process water which contains the water-soluble compounds of the fruits. The quantity of water and soluble compounds depends on the extraction system employed (Table 2).

Compost is stable and organic-rich. It is important to evaluate its composition before spreading to gauge its quality. Analyses are performed to make sure the pomace has a low oil content and complies with the rules and regulations. It is preferable, therefore, to use olive pomace that has already been depleted and that therefore has a low moisture content and minimal oil content.

Table 4: Olive pomace composition after composting

Compost composition (%)	
Moisture (%)	90–95
Organic compounds (%)	3–10
Mineral substances (%)	50–70

Photo 4: Olive pomace compost

Practice 2: Timing of composting

The best period for composting is between November and December.

Practice3: Composting techniques

Composting is one of the techniques available to recycle the by-products of the olive, notably olive pomace. It is a process of aerobic biological decomposition under controlled temperature conditions during which the organic substances are converted into humus and CO_2, water and heat are released.

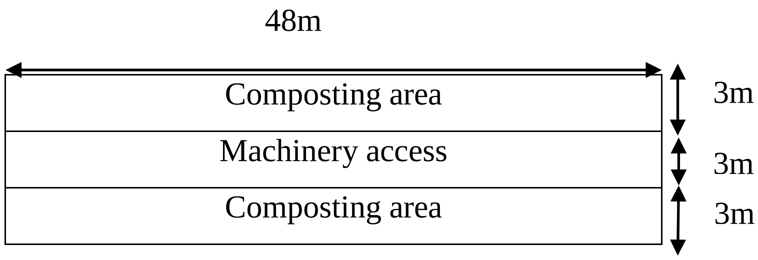
Several steps are involved in composting olive pomace:

Preparation of the pomace:

This step entails piling the compost into mounds 1–1.5 m high and 3 m wide on a concrete platform that is 9 m wide to allow machinery access to turn over the compost

Photo 5: Composting setup

The platform length depends on the intended amount of compost. It is recommended to cover the composting platform with plastic sheeting to facilitate optimal composting conditions (humidity and temperature).



Schematic outline of the composting platform

Other substances can be added such as olive and vine wood prunings, olive leaves, grape stalks or cattle manure to give good, well structured compost. Pruned olive wood is used after being crushed into small 1.5 cm pieces in a shredder.

Photo 6: Olive pruning shredder

Another recommendation is to add nitrogen (urea) at a rate of 2% of the total quantity of compost to stimulate microbial activity in the compost.

Photo 7: Application of urea

- Compost turnover:

To make sure the compost is properly aired and the temperature does not build up excessively (it must be less than 60°C) the compost must be mechanically turned over at regular intervals of four or five days, particularly during the first 45 days of composting.

Photo 8: Turning over the compost

- Compost moistening:

The moisture content of the compost must be kept at about 60% by regularly moistening the compost mounds. If the compost is underwatered, powdery mildew appears indicating slower microbial activity. All that needs to be done to resume the decomposition process is to moisten the compost. Adding water should be avoided at the end of the decomposition process because it is not advisable to increase the moisture content as this translates into higher transport costs. Conversely, moistening to excess (dry matter content of less than 20%) leads to poor anaerobic conditions.

Practice 4: Evaluation of compost maturity

It is absolutely essential to evaluate the maturity of the compost before use because the lack of organic matter stability leads to modifications in the physical, chemical and plant toxicity characteristics. There are four types of method for this purpose: empirical, chemical, physical and biological.

- Empirical methods:

Empirical methods are based on visual inspection and touch. Compost is considered to be mature when the raw materials are no longer identifiable, it smells of wet soil as opposed to ammonia, and it is soft to the touch.

- Physical methods:

➢ Remoistening test: a sample of compost is moistened at 50% while monitoring the temperature. If the temperature does not increase, the compost is stable and therefore mature. In theory, the temperature must be kept at between 20 and 30 °C.
➢ Sieve test: approximately 5kg of compost is sieved through a 25mm-mesh sieve and the filtrate is weighed. If the weight is between 4 and 5 kg, the compost is mature.

- Chemical methods:

➢ pH test: in theory, compost that has undergone optimal decomposition will have a neutral to slightly basic pH.
➢ Ammonium/nitrate ratio: mature compost must contain more nitrates than ammonium. Generally, a nitrate/ammonium ratio of 2/1 or more is acceptable. This test is not valid if the compost has been enriched with a mineral ammonium and/or nitrate based fertilizer.
➢ Chromium test: a sample of dried compost crushed to a size of 0.1 mm is mixed with 10 ml of potassium dichromate ($K_2Cr_2O_7$, 1N) and 20 ml of sulphuric acid. If the sample turns green, owing to the presence of the Cr_3^+ ion, the compost is not yet mature. If it turns brown, it is mature.
➢ C/N ratio: this ratio decreases during composting owing to biodegradation of the organic matter and the resultant release of CO_2. Other ratios can be used to glean other information about the progress or completion of the composting process: carbon/phosphorus; organic nitrogen/mineral nitrogen; nitric nitrogen/ammonia nitrogen (which are stable when the compost is mature).

- <u>Biological methods:</u>

Compost maturity can be checked by performing plant toxicity tests, i.e. by conducting germination tests using *Lepidium sativum* seeds which are placed on Petri dishes lined with filter paper soaked with an aqueous extract of the compost.

Two concentrations (50 and 70%) of the extract are obtained by separating the liquid phase by pressure. The germination rate at the two concentrations is calculated from the formula:

GI (50 or 75%) = (Gs*Ls/ Gc*Lc)*100

where:

Gs is the mean number of germinated seeds in the sample;

Gc is the mean number of germinated seeds in the control;

Ls is the mean radicle length in the sample;

Lc is the mean radicle length in the control.

The germination capacity is obtained by calculating the arithmetic mean of the values obtained at the two concentrations (50 and 70%):

$$GI\ \% = \frac{GI\ 50\% + GI\ 75\%}{2}$$

The results are interpreted as follows:

- No plant toxicity at GI values > 70%: the compost is mature.
- Risk of plant toxicity at GI values between 40 and 70%: the compost is moderately mature.
- Plant toxicity at GI values < 40%: the compost is not yet mature.

Practice 5: Timing of spreading

The best period for spreading is from February to March, i.e. two or three months after composting. Rainy days and soils at pH <6 should be avoided.

Olive pomace and VW can be spread on the same plot provided the recommended periods for application are respected, i.e. between November and March for VW, and from February to March for olive pomace compost.

Practice 6: Compost application rates

The recommended application rate is 5 kg/m^2, i.e. 5 t /ha every three years. The compost is spread between the rows of trees in the orchard and may also be applied to other crops such as vine, fruit trees and annual crops: maize, tomato, bean, artichoke….

Photo 9: Compost spreading

Practice 7: Practices after compost spreading

The soil needs to be lightly ploughed to work in the compost nutrients. As with VW, this helps to improve the soil structure.

Controlled spreading of VW and olive pomace compost is economically and environmentally beneficial and conducive to sustainable, environmentally friendly olive growing.

The results of project CFC/IOOC/04 show very conclusively that VW is a very valuable product from both the economic and environmental points of view. Reuse of VW leads to a sharp decrease in pollutant wastewater and this by-product becomes an asset that reduces the use of chemical fertilizers, provides protection from erosion, improves soil fertility and bacterial activity and enhances crop yields, all for the benefit of farmers.

The application of VW and olive pomace compost is the perfect answer to limit loss of soil fertility when organic matter content falls below 1%.

This is particularly relevant in agricultural areas where the environmental conditions (hot and arid) make it particularly hard to maintain soil fertility with the ensuing serious consequences of desertification.

Olive pomace composting produces stable, fertilizing organic matter that is free from pathogens (mycelia or bacteria) and weeds owing to its biofumigation effect. This kind of fertilizer is very worthwhile for base fertilization when planting and for maintenance fertilization because it heightens the effectiveness of the mineral fertilizers applied. Consequently, the reuse of olive pomace as a compost has many advantages for soils and crops: it improves the chemical, biological and physical properties of the soil (water retention, cation retention in sandy soils, structural stability and air circulation) and, when combined with soil amendments, it facilitates plant growth by improving plant physiology and nutrition.

From now on, the application of VW and olive pomace compost should be considered a routine agricultural practice like pruning, fertilization and irrigation, provided it is distributed evenly (by choosing equipment with an adjustable flow rate) and the recommended rates are not exceeded.