

## **Cultural techniques and varietal aspects in olive: traditional and innovative approaches for semi-arid environments**

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Olive growing in Sicily is spread in 180 000 hectares and is located in a wide range of environmental conditions, both from a climatic and a pedological point of view, owing to the particular morphological and topographical features of the region. The complexity in the environmental characters of olive growing areas in Sicily leads to the development of cultural techniques aiming to adapt the environmental resources available in each cultural area to the ecological requirements of the species.

The geographic location of Sicily, an Island in the middle of the Mediterranean, has favoured the introduction and, along the centuries, the development of an olive germplasm that, according to a recent survey, is composed by about 40 cultivars (Barone et al., 1994). This high environmental diversity, apart from ensuring good productive levels in each cultural area, promoted the high cultivar differentiation which can be observed among the several olive oils which, thanks to the appropriate cultural practices, can reach very high qualitative levels. Several oils are protected by their Protected Designation of Origin (PDO) seal and are appreciated both on the national and the international market (Caruso et al., 2002). In spite of the high variability of the Sicilian olive varietal pool, only few cultivars (about 10), are adopted in the majority of olive growing areas of Sicily and among them, in order of importance, can be named: Biancolilla, Nocellara del Belice, Cerasuola, Ogliarola Messinese, Santagatese, Nocellara Etnea, Tonda Iblea, Giarrappa e Santagatese. These cultivars, under the environmental and cultural pressure, gave origin, along the time, to several clones that, likely, allowed a better adaptation to the several different ecological conditions which can be found in Sicily.

Differences in water availability, both due to the hydrological characters of the soils and the high variability in annual rainfall among the various growing areas, may have been played a significant selective pressure, largely affecting the diffusion of olive cultivars in Sicily, a region in which, still today, 95% of the olive groves are not irrigated. Also cultural practices adopted in relation to the cultural environment, could have contributed to the spread of some cultivars in spite of others.

In fact, even if large part of the Island, in the altitude's belt comprised within 0 m and 500 m a.s.l., is to be considered favorable to olive growing, the uneven distribution of precipitation and the yearly trend of temperature, particularly where the culture insists in shallow soils with low water storage capacity, make the water shortage detrimental to the most important biological stages for fructification, often preventing the expression of the vegetative potential of the olive and the completion of the reproductive processes. Water deficit during the vegetative season is considered, in fact, one of the major causes of alternate bearing, low production levels and scarce fruit quality.

### *Climate and olive growing in South-Western Sicily*

Considering the cultural areas of the coast-line along the South-Western side of the Island, between the towns of Sciacca and Mazara del Vallo (Lat. 37.30N), the analysis of climatic parameters of the period 1964-1990, shows an average annual air temperature of 18° C, with a min of 7.5° C (February) and a max of 31.1° C (July). Very rarely temperatures fall below 2° C or rise above 42° C.

Average annual rainfall of this olive district ranges between 480 mm (Mazara del Vallo) and 640 mm (Partanna). Larger part (290-380 mm, about 60%) of the annual rainfall occurs in the period December-April, 8% (38-52 mm) in May-August and the remaining 32% (152-208 mm) in the fall.

From the combined analysis of monthly average temperatures and cumulative rainfall data (*Peguy*), it results that climate, in this area of Sicily, is temperate with a drought period between May and September.

Potential evapotranspiration (ETP) varies between 830 and 900 mm/year.

From the soil water balance (*Thornthwaite-Mather*), it can be deduced that, with the exception of January and February, the only months of the year during which a water surplus occurs, in the remaining 10 months ETP is higher than precipitation so that water deficit conditions prevail. In fact, the onset of the “re-charge” phase, generally, begins only in November.

### *Short notes on ecophysiological aspects of the olive tree*

In the Olive, the rate of photosynthesis is affected by temperature, light intensity and water availability.

The relationship between photosynthesis and temperature is bell-shaped, with values of base temperature, optimum temperature and critical temperature, respectively, of 4°, 25-30° and 40° C (Tombesi, 2002).

The response of photosynthesis to light intensity is asymptotic in the range between 20-30 (light compensation point) and 1600  $\mu\text{mol m}^{-2} \text{sec}^{-1}$ .

Also the relationship between photosynthesis and soil water availability is asymptotic in the range of soil water content included between wilting point and field capacity. The higher increase in photosynthetic rate, however, occurs when soil water content increases from wilting point to about 50% of field capacity; above this water availability level, gains in photosynthetic rate, in response to increases in water availability, are minor.

The olive, also, even at very low pre-dawn leaf water potential can sustain a limited transpiration, being able, by this way, to extract water from the soil up to -2.5 MPa water potential.

### *The olive tree annual growth cycle*

The first step of the fructification cycle is the *new shoots growth* on which the flower buds *induction* and the *differentiation* follow. The time of flower bud induction is not exactly detected yet but, recently, Fabbri and Alerci (1999) suggested that, under the Sicilian environmental conditions, in spring a “first set of stimuli” select a number of likely flower buds; such “candidate” flower buds remain at the same stage until autumn when, if favourable conditions occur, they develop in completely differentiated flower buds. Both in spring (*flower bud induction phase*) and autumn (*flower bud differentiation phase*), the amount of the buds along the new shoots that will be stimulated to develop in a two-step process toward flower buds largely depends on the balance of environmental, hormonal, nutritional and cultural factors among which soil water availability plays a fundamental role.

In the following spring, on one-year old shoot, after blooming and fruit set, growth of olive drupes takes place by cell multiplication. During summer, soon after pit hardening, increase in weight and volume occur by cells enlargement and oil accumulation. Epicarp colour changes and ripening takes place, in many of the Sicilian varieties in autumn. The period and the intensity of fruit growth and oil accumulation are expressed differently according to the variety but can be largely affected by environmental conditions and cultural techniques. Oil accumulation in the drupe usually starts just before pit hardening (end of July in Sicily) but the intensity of accumulation and the final content depend on the flow of carbohydrates to promote the synthesis of oil in the pulp. Although the period of intensive oil accumulation usually starts early, depending on the cultivar, it can last for a long time, even if at a lower intensity. Optimum temperatures (not higher than 30° C) together with soil water and nutrient content during the entire period of fruit growth and development, allowing high photosynthesis rate and, thus, a large availability of assimilates for the tree, favour the oil accumulation into the drupes.

Climatic conditions and time of intensive and total fruit dry matter accumulation should be taken into account when choosing the varieties for each zone so that compatible growth trend and oil synthesis are favoured and severe water stress is avoided.

For this reason, usually the introduction of foreigners cultivars, particularly from areas where the environmental conditions are quite different respect to those of growing ones should be avoided, unless acclimation trials have been previously carried out.

### **Cultural techniques**

#### Fertilisation

Traditionally, in the Mediterranean countries the olive orchard is considered to require poor nutrient supply. In spite of this, more recent studies have shown that nutrients uptake in an irrigated olive orchard, although minimal during the non productive phase, arises up soon after the onset of fruit production. Under irrigated conditions Xiloyannis and coworkers (2002) calculated a nutrients removal for

canopy, root growth and yield of 9; 1.5; 8.5; 12.5 and 0.7 Kg/ha<sup>-1</sup> year<sup>-1</sup> for N; P<sub>2</sub>O<sub>5</sub>; K<sub>2</sub>O; CaO and MgO but those amounts can arise up to 186; 30; 163; 213 and 26 Kg/ha<sup>-1</sup> year<sup>-1</sup>.

In Sicily most of olive orchards are under rainfed conditions but grower, soon after planting, to push up vegetative growth and to reduce the not bearing phase, usually supply an excessive amount of nutrients during winter. Under dry land conditions nutrients foliar fertilisation, as an addition to the soil application, seems to be a viable technique to increase fertilisation efficacy.

### Soil management

Traditional soil management in rainfed olive orchard (up to eight tillages during the season) is aimed to the reduction of evaporation, rainfall conservation and weed control through biomass moving. In fact, tillage may enhance soil water storage when it increases infiltration due to loosening of surface crusts or other slowly permeable soil layers, increases detention storage on the surface to provide more time for infiltration, but avoid water storage if it results in a smooth, unstable soil surface that readily seals due to raindrop impact, thus increasing runoff. Tillage also increases evaporation of water previously stored when it exposes moist soil to the atmosphere.

Biomass retention on the surface by using no-tillage or cover crops management, on the contrary, are highly effective for protecting soil surfaces and maintaining favourable infiltration rates. In addition, use of no-tillage maintains soil micro pore continuity, which not only results in a more rapid infiltration, but generally also leads to store water deeper in the soil where water is less subject to evaporative losses. Decreasing evaporation potentially increases water available for transpiration, thus improving photosynthesis and WUE. Tillage also determines a high soil organic matter mineralisation due to the oxidation induced by soil bulk density change.

In Sicily many hectares of olive orchards are cultivated on an average slope of 35%, consequently they are subjected to high erosion risks both for rainfall characteristics and timing and extreme soil organic matter reduction due to soil tillage. Especially during fall-winter rainfall soil susceptibility to erosion is high because lack of mulch (cover crops).

Use of one or more herbaceous species cover crop and /or green manure, may also be an opportunity to limit soil organic matter degradation and an opportunity to improve soil humus reservoirs.

Cover crops and green manure management, in fact, represent an efficient tool for agro-ecological cropping system efficiency improvement, in terms of autonomy, stability, external inputs reduction and environmental risk.

In a research programme, still in progress in Sicily, after three years of trials, all the leguminous crops (Vetch, Subclover, Medic) furnished more nitrogen than "spontaneous" cover cropping. Among the leguminous, vetch produced more biomass.

Cover cropped system showed a larger water use (20-25%) in comparison to "conventional" (tillage) treatment (up to June).

Soil moisture (June) revealed a high water demand by self reseeding species (Subclover) that determined the need to diversify species management. Reseeding species, in fact, just to warrant selfreseeding aptitude, should be moved only in right and left side along the row of the olive growth.

Treatments also influenced soil organic matter content: vetch determined the highest values in relation to biomass production; on the contrary the “conventional” management caused a soil organic matter reduction probably because the high mineralisation level due to soil tillage. “Spontaneous” cover of olive orchards was characterised by a sufficient soil organic matter.

Olive intercropping with leguminous crops determined an ecological improvement to olive ecosystem in terms of soil fertility; in fact, soil organic matter and nitrogen increases were recorded. In addition to these positive effects some others must be considered. In fact, generally, frequent tillage (up to eight times) can determine on one hand an evaporation reduction (even if for a short period) but, on the other, increases soil erosion because soil structure depletion.

Soil erosion control by cover crops resulted very effective if early sowing or reseeding is carried out (September/October) because typical rainfall aggressiveness in that period.

Also natural covering resulted very efficient for soil erosion control because environment adaptability of weds and their fast growth depending on September rain. In conclusion, there are not doubts on cover crops influence on soil quality and sustainability improvement. However, cover crops systems, in the semi-arid environments, needs further studies as far as species choice and manuring stage are concerned, in order to better reduce its competition for water resources.

### *Planting system and pruning*

Similarly to other fruit-tree species, production per unit of land area, in the olive, is positively related to the percent of incoming solar radiation intercepted which, in turn, depends on planting density, canopy volume, canopy foliage density and leaf area index. To increase the amount of light intercepted in an olive orchard it is possible to act on different ways: on planting densities, on canopy volume, on tree shape, on canopy foliage density and by the use of adequate pruning systems.

Under Mediterranean climate conditions, where the rainfall/year is around 600 mm, canopy volume per hectare should not be higher than 8000-9000 m<sup>3</sup>. Another condition is that the tree has to be shaped and trained to fit to mechanical harvesters, like the trunk shakers; to increase the shaker efficiency canopy volume of the single tree should not exceed 40 m<sup>3</sup> (Tombesi, 2002). Pruning is a crucial technique to maintain and to sustain tree productivity together with fruit quality. Under rainfed conditions pruning can significantly affect soil water availability. In Spain it has been found that the moisture content in the 0-80 cm layer was higher in olive orchards pruned severely (8.000 m<sup>3</sup> of canopy volume per ha) than in orchards pruned less severely (10.000 m<sup>3</sup> per ha) (Civantos and Pastor, 1996). This result also indicates that during the summer the less severely pruned trees had negative consequences for

fruit growth. Indeed, in the Sicilian conditions, particularly in the area of the 'Nocellara del Belice' (Mazara del Vallo) such a practice of severe summer reduction of the canopy is traditionally practised in order also to regulate crop load, and thus to reduce fruit competition, in orchards for table olive production. However, it is well known that for thinning purpose other technical solutions can be adopted that not interfere with root/shoot ratio. On such an argument ongoing field tests are carried out at the University of Palermo.

By the 90's, in order to increase the olive production and to reduce the labour costs, pushed up by the scarcity and costs of hand labours, some Sicilian olive growers, are looking at very intensive planting systems (1000-3000 trees ha<sup>-1</sup>) developed in central Italy and in Catalonia. These planting systems, based on low vigorous cultivars, on the whole, allow to increase the production per m<sup>2</sup> of land surface and to pick the fruit up with a modified overhead vinegrape harvester that is able to harvest 5 tons of fruit/hour.

Unfortunately such kind of plantings, due to the very high LAI, present a water demand so high that, under rainfed conditions, its feasibility is highly questionable.

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