Productivity and oil characteristics in a superintensive olive planting system in Central Italy

E. Marone[1], A. Mersi[2], A. Ottanelli[3], e P. Fiorino[3]

[1] University of Teramo, Faculty of Agriculture, Department of Food Science, Via C. Lerici, 1, 64023 Mosciano S. Angelo (TE), Italy
[2] Technical Consultant on olive growing, milling techniques and systems, and olive oil quality
[3] University of Florence, Faculty of Agriculture, Department of Hortscience, Viale delle Idee, 30, 50019 Sesto Fiorentino (FI), Italy

e-mail of corresponding author: pfiorino@unifi.it

Summary

A superintensive planting of cultivars Arbequina i18, Arbosana i43, Koroneiki i38, Coratina, FS 17 and Don Carlo was carried out at the "Castello di Torrimpietra" farm near Rome in March 2006. In 2008 several of these cultivars produced considerable amounts of olives, which were harvested mechanically; the olives were taken to a mill for processing within 4 h.

The present paper reports the productive data and yields for the six studied cultivars; all obtained oils were analyzed and evaluated by an expert panel.

The production results can be considered preliminary as they refer to the first harvest obtained from the third vegetation, which was marked for several cultivars known for their precocious fructification. 'Arbosana' produced 7 t ha^{-1} of olives (with more than 1 t of oil per ha); 'Arbequina' and 'Koroneiki' produced 6,5 and almost 5 t ha^{-1} respectively. Analysis of the extra virgin oils revealed that they were all very good or good in terms of their physical-chemical and sensorial profiles.

Kew word: productivity, oil composition, oil evaluation, superintensive planting

Introduction

In the last five years, superintensive plantings (SIP) of olive have attracted increasing attention by Italian technicians and researchers, however they have particularly stimulated interest, perplexity and discussion amongst producers.

Table 1 – Average production/ha (kg of oil for Andalusia, kg of fruits for Tarragona and Puglia) obtained from superintensive plantings in three different zones (modified from Loreti, 2007).

CULTIVAR	ANDALUSIA Yield/year (kg of oil)					PUGLIA Yield/year (kg of fruits)		TARRAGONA Yield/year (kg of fruits)				
	2°	3°	4°	5°	6°	3°	4°	2°	3°	4°	5°	6°
ARBEQUINA	0	2.484	2.475	3.047	1.282							
ARBEQUINA IRTA-i18	0	2.578	2.003	2.911	1.294	1.200	1.300	1.235	6.727	4.963	13.493	9.308
ARBOSANA	71	2.762	1.684	4.298	1.405	2.200	3.700	900	5.348	3.175	13.644	6.602
CANETERA								500	2.433	6.351	8.339	5.932
CIPRESSINO							300					
CORATINA						300	500					
FRANTOIO						0	0					
JOANENCA								0	1.660	3.981	11.894	9.556
FS 17 ®	0	660	436	1.284	159	3.200	3.500	0	2.026	872	10.216	2.145
KORONEIKI	519	3.762	1.055	2.646	855			0	2.708	6.003	7.646	8.606
LECCINO						300	500					
URANO						0	1.300					

The first SIP were realized in 1994 in Spain (Mateu Cabre *et al*., 2009). After only three years, the technique had spread into the south of France, by 1999 it had reached Tunisia and later, with ever increasing areas, North and South America and Australia. Despite some uncertain data, the current estimate for worldwide plantings of this type is more than 100.000 hectares of olive trees.

In Italy the first (experimental) SIP took place as recently as 2002 (Godini *et al*., 2006). There have been numerous discussions regarding the validity of the SIP system in Italy, and due to a lack of experimental means, new plantings have been extremely modest, realized in small areas by private growers, and did not exceed 100 hectares in 2006 (Sportelli, 2006).

The success of this technique is based on high efficiency of the productive canopy (which should be around 1.000 g $(m^3)^{-1}$ of vegetation); it is obtainable by some cultivars with adequate cultural techniques (i.e. fert-irrigation, accurate plant protection) from the third-fourth year after planting. Highly efficient productivity combined with highly efficient harvesting (1 ha, equal to about 8.000-10.000 m^3 of vegetation harvested in 2,5 h) permits a notable reduction of production costs.

The SIP model has two problems: uncertainty regarding the duration of the productive life of the planting, and the limited varietal platform currently available, irrespective of the location of new plantings. This latter problem could lead (as feared by some traditional olive-growing countries) to product quality that is not up to the standards requested by the market.

Despite the importance of the questions raised and the outlook for development, productivity data for the plots and the constituent and organoleptic characteristics of the product are modest.

Table 1 presents data from SIP during the first years of production. It can note that: there are only a few cultivars which enter production sufficiently early to adequately respond to the increase in density; it is not always possible to reach and maintain the desired productive levels (9-12 t ha^{-1}, Loreti, 2007) in different environments, even with the most suitable cultivars; and latent “defects” (e.g. sensitivity to *Verticillium dahliae*) can even further limit the range of possible choices.

Data regarding oil characteristics of the cultivars which are potentially suitable are equally limited. With regard to the acidic composition, ‘Arbequina i18’ showed to be sensitive to the effect of temperature during fruit growth and maturation. In the most recent literature, oleic acid values can be found from slightly more than 58% (Allalout et al., 2009) to 71% (Mersi, 2008b). Recent data regarding some parameters of the oil constituents of cultivars considered suitable for SIP (Mersi, 2008a) are presented in Table 2. The data were collected from samples from various parts of Italy; the time of harvesting was not homogeneous. Information regarding the cv Koroneiki are lacking. Oil from this cultivar would, in Tuscany, be characterized by high value for oleic acid (around 80%); according to the available data this is a cultivar with agronomic interest in all planting conditions.

Table 2 – Levels of some compounds present in oil of cultivars considered suitable for SIP (modified from Mersi, 2008).

CULTIVAR	LOCATION	OLEIC ACID (% of tryglicerid) (C 18:1)	POLYPHENOLS (mg/kg)	TOCOPHEROLS (mg/kg)
ARBEQUINA IRTA-i 18	Toscana	69,27	90	290
ARBOSANA IRTA-i 43	Puglia	72,42	224	362
FS 17 ®	Umbria	77,03	305	180
DON CARLO ®	Umbria	81,19	639	148

Therefore, it was decided to verify the productive and qualitative response of a certain number of cultivars raised according to SIP criteria in cultivation conditions in a set area of central Italy.

Materials and methods

Trials were conducted at the “Castello di Torrimpietra” farm (41° 53’ 44’’ N Lat, 12° 14’ 03’’ E Long, 30 m a. s. l.) in the province of Rome, in an area influenced by the vicinity of the sea. The plot (5 ha) is made up of a nearly flat body with fertile soil having medium texture and tending toward clay. The main planting was carried out in March 2006 using the following cultivars: Arbequina, Arbosana, Don Carlo, FS 17 and Koroneiki; ‘Coratina’ was also planted but by 2008 it had not yet entered into production.

Self-rooted material, 6-8 months old and 30-40 cm height, was used. Each plant was attached to a support, tied at 180 cm height. Three planting distances were used, keeping the inter-rows at 3,8 m and varying the distance on the rows: 1.6 m for ‘Arbequina’, ‘Arbosana’ and ‘Koroneiki’, 2,0 m for ‘Don Carlo’ and ‘FS 17’, and 2,4 m for ‘Coratina’.

All cultivars received fert-irrigation with fertilizers supplied from May to September and a volume of water of about 1.500 m^3 ha^{-1}. Ordinary methods of plant protection for a young intensive planting were used, including defence against *Palpita (Margaronia) unionalis* and *Otiorrhynchus cribricollis*. In spring 2008 ‘Arbequina’, ‘Arbosana’, ‘Don Carlo’, ‘FS

17’ and ‘Koroneiki’ flowered abundantly and in October of the same year harvesting began (harvest dates are indicated in Table 3) using a self-propelled harvester (Gregoire G-107 with harvesting capacity of about 2,5 h ha^{-1}).

Milling was carried out the same day as harvest using a three-phase system at a working temperature of about 27 °C with optimization of times and processing for each cultivar.

The weight of product from each plant of each cultivar and respective yield of oil at the mill were recorded. Oil samples were analyzed for acidity, peroxides, methyl esters of fatty acids, and colorimetric polyphenols and evaluated for their organoleptic profile by a panel of eight expert tasters, listed in the registry of oil tasters.

Results

The principal data regarding the harvest are collected in Table 3. From the values in the first year of production, ‘Arbosana’ emerges as the cultivar with the greatest per plant productivity: at a density of 1.645 plants ha^{-1} it supplied more than 7 t ha^{-1}, and 1 t of oil. ‘Arbequina’ (6,5 t) and ‘Koroneiki’ (5 t) follow, with ‘FS 17’ (2,7 t) and ‘Don Carlo’ (2,0 t), lagging behind.

Table 3 – Production and yield of SIP at Torre in Pietra in 2008 (third vegetation).

CULTIVAR	Plants/ha (n)	Planting distances (m)	Olive yield/ha (kg)	Olive yield/plant (kg)	Harvesting time	Oil content (%)	Oil prod./plant (kg)	Oil prod./ha (kg) 1,5 m on the row	Oil prod./ha (kg) 1,75 m on the row
ARBEQUINA IRTA-i 18	1.645	3,8 X 1,6	6.480	3,94	23-ott-09	13,76	0,54	891,8	713,5
ARBOSANA IRTA-i 43	1.645	3,8 X 1,6	7.138	4,34	24-nov-09	15,34	0,67	1095,2	876,1
DON CARLO ®	1.316	3,8 X 2,0	1.959	1,49	6-nov-09	15,06	0,22	369,1	295,3
FS 17 ®	1.316	3,8 X 2,0	2.736	2,07	15-ott-09	15,45	0,32	526,1	420,9
KORONEIKI IRTA-i 38	1.645	3,8 X 1,6	4.983	3,03	6-nov-09	14,17	0,43	706,3	565,0

Table 4 – Analytical results of monovarietal oils from the tested cultivars (columns 2-6), of an oil produced from olives of the local area (column 7), and of a Tuscan oil from an inland area (column 8).

	ARBEQUINA IRTA-i18	ARBOSANA IRTA-i43	DON CARLO ®	FS 17 ®	KORONEIKI IRTA-i 38	LOCAL	INLAND ZONE
ACIDITY (%)	0,12	0,17	0,14	0,16	0,17	0,23	0,11
PEROXIDES (meq O_2/kg)	10,0	7,0	8,3	9,4	7,1	12,2	7,1
POLIPHENOLS (mg/kg ac. gallico)	230	221	338	258	284	249	402
PALMITIC ACID (%)	15,05	12,66	12,22	13,26	11,24	13,77	11,95
OLEIC ACID (%)	72,0	77,3	78,2	73,2	80,1	73,6	76,7
LINOLEIC ACID (%)	7,90	5,33	5,22	9,28	4,28	7,61	6,89
LINOLENIC ACID (%)	0,52	0,61	0,58	0,88	0,58	0,68	0,62

Table 5 – Results of the panel test.

CULTIVAR	PANELLIST A	B	C	D	E	F	G	H	AVERAGE SCORE	ORGANOLEPTIC EVALUATION
ARBEQUINA IRTA-i18	8,50	7,50	8,00	8,50	8,00	7,00	7,00	7,50	7,75	ExtraVirgin-Very good
ARBOSANA IRTA-i43	7,00	7,00	7,00	7,50	7,00	7,00	8,00	7,50	7,25	ExtraVirgin -Good
DON CARLO ®	7,00	7,00	7,50	6,50	7,00	7,00	7,00	7,00	7,00	ExtraVirgin -Good
FS 17 ®	7,00	7,00	7,00	7,50	7,00	7,50	7,00	8,00	7,25	ExtraVirgin -Good
KORONEIKI IRTA-i 38	7,50	7,50	7,50	7,50	7,50	7,00	8,00	7,50	7,50	ExtraVirgin -Very good

Column 8 shows the principal data of agronomical interest: the effective production of oil per plant, which includes production and at-mill yield. Also in this case, 'Arbosana' ranks first, with oil production three times that of 'Don Carlo'. Table 4 collects the analytical results of the oils of the five investigated varieties. In order to provide general indications and points for evaluation, the table also includes the results of analyses carried out in the same laboratory on an oil from a local mill and another from a inland zone of Tuscany. All the tested oils were extra virgin. With regard to acidic composition, cultivar Arbequina demonstrated 72% oleic acid which, probably due to the effect of the elevated latitude, was slightly lower than the value for the traditional oil of the area (73.6%). As expected, 'Koroneiki' had the highest oleic acid content (80%), while 'FS 17' was characterized by the highest linoleic acid content (9.3%). The content in polyphenols is medium to medium-high and the three cultivars, Don Carlo, FS 17 and Koroneiki, presented values higher than the local oil.

The panel test evaluation of the five considered oils confirmed that extra virgin oils were obtained which ranked as good (or very good) in quality with scores from 7.0 for 'Don Carlo' to 7.75 for 'Arbequina', with relatively homogenous scoring by the panellists (Table 5).

Figure 1 presents the principal organoleptic characteristics for the five cultivars. From the figure it is evident that cultivars Arbosana and Arbequina have moderate "bitter" values, 'Don Carlo' is the most "spicy" (average higher than 6/10), while for the "fruity" characteristic 'Koroneiki' is certainly the oil with the highest values (near 7/10 on average).

Discussion

Overall, the productive data demonstrate that there is a real possibility for properly applied SIP to attain, from the first years of planting, quantitatively important productions, confirming the values obtained in the region of Tarragona in Spain (Table 1). There was strong differentiation among the compared varieties: five were precocious or very precocious in entering production, while 'Coratina' was still late compared to the former group.

The fact that one cultivar (Arbosana), already by the third year, produced 1 t ha^{-1} of oil is an important result, the amount representing 50% of the theoretical amount obtainable from the cultivated olive.

The two Italian cultivars present lower productive levels but before judging their real productivity under SIP conditions it is necessary to wait until the plants reach their productive maturity, i.e. still three to four more years of growth.

With regard to the characteristics of the produced oil of each cultivar, it is evident that in compositional terms, they are high profile oils with levels for chemical parameters which are comparable to or greater than those of local production, and for some even greater (e.g. 'Koroneiki' for oleic acid) than the reference sample from an interior zone of Tuscany.

Despite the climatic trend for the year (Fig. 2) which was characterized by a rainy spring and especially autumn, the polyphenol values of the monovarietal oils remained high or medium-high, and almost always higher than the local sample.

The panel test evaluation, carried out by experts, underlined the quality of the oils (classified as extra virgin), rating from "good" to "very good". Together, these results demonstrate that with an adequate knowledge of SIP cultivation techniques it is possible to reach precociously a high level of productivity and that with particular attention to harvest-separation operations it is possible to suitably manage oil characteristics if the environmental conditions allow fruit quality levels to be reached.

The trials should be considered still in the initial stages as it will be necessary to also evaluate the productivity and product characteristics of other cultivars planted later in the plots, following the evolution of production for another three to four years to verify the compatibility of various cultivars with set planting distances (possibility, cost and pruning intensity).

Furthermore, it seems even more evident that in-depth study and research on the mechanisms which lead to the formation of fruits and oil, with the establishment of comparative test fields (e.g. intensive/superintensive), is still needed. These tests could, in different zones of Italy, help to orient growers toward the most convenient densities and the most suitable cultivars.

Finally, new commitments in research are needed as changes in technology open the way toward genetic improvement to identify the most suitable material to use in various agronomic or environmental combinations, which may exist in our national olive-growing context, both in intensive and SIP plantings, as well as with regard to the needs of the market.

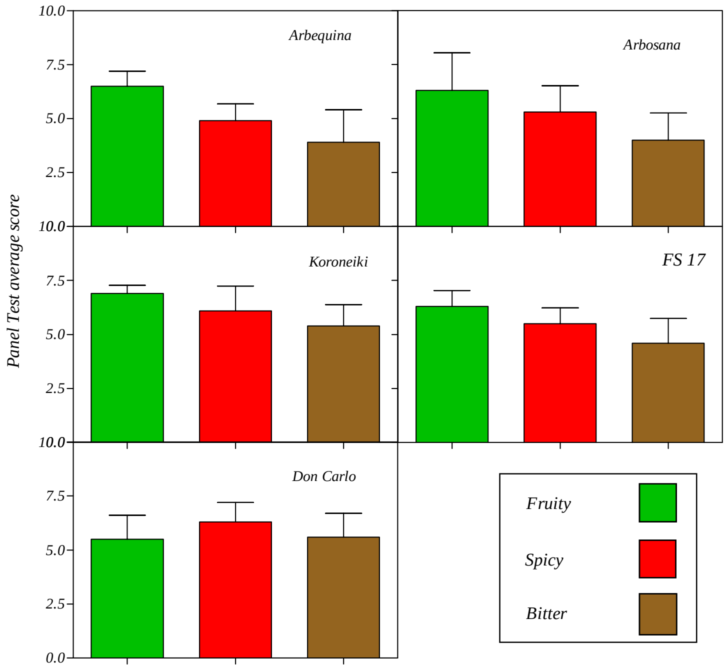

Figure 1 – Principal organoleptic characteristics of the monovarietal oils for the five tested cultivars (2008 harvest).

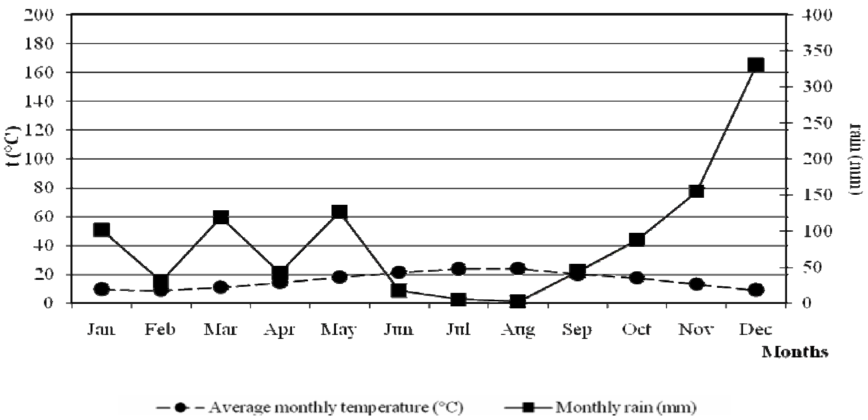

Figure 2 – Climatogram (2008) for the Torre in Pietra (Rome) plot.

References

Allalout A., Krichène D., Methenni K., Taamalli A., Oueslati I., 2009. Characterization of virgin olive oil from Super Intensive Spanish and Greek varieties grown in northern Tunisia. Scientia Horticulturae [120], 77-83.

Godini A., Camposeo S., Scavo V., 2006. Gli aspetti agronomici dell'olivicoltura superintensiva. L'Informatore Agrario [1], 65-67.

Loreti F., 2007. Alta densità: rivoluzione globale nelle tecniche di coltivazione dell'olivo. Frutticoltura [7-8], 56-70.

Mateu Cabré J., Rius Garcia X., Lacarte Peña J.M., 2009. Il superintensivo avanza nel mondo ma senza fretta. Olivo e Olio [4], 4-8.

Mersi A., 2008. Superintensivi made in Italy. Un confronto sensoriale. Olivo e Olio [2], 36-41.

Mersi A., 2008. The Quality of Olive Oil Produced Under the Super High Density System (SHD). Olint [7], 17-21.

Sportelli G.F., 2006. Nome in codice, Agromillora. Aiuto, arrivano gli spagnoli. Olivo e Olio [7-8], 8-9.