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An Alternative Method to Managing Olive Orchards: The Coppiced System

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Summary. **An alternative method to managing olive (*Olea europaea* L.) orchards for oil production is described. Using the coppiced system, the orchard is divided into 10 plots and all trees in one plot are coppiced year 1, all trees in a second plot are coppiced year 2, etc. In this way, the olive orchard consists of 10 different-aged plots after 10 years. Then a new cycle is started by coppicing trees in plot 1 in year 11, those in plot 2 in year 12, and so on. Since hardly any pruning is done after coppicing, the main advantages of this innovative management method are to reduce labor costs and the need for skillful labor, without negative effects on fruit yield, oil yield, or alternate bearing. Pesticide application, weed control, and fertilization were performed according to standard commercial practice. As a result, this system is more convenient than other training systems used for olive trees, it is suitable for renewing old trees, and can be adopted under many cultural conditions. The coppiced management system is compatible with soils of low fertility and is sustainable for long-term olive oil production.**

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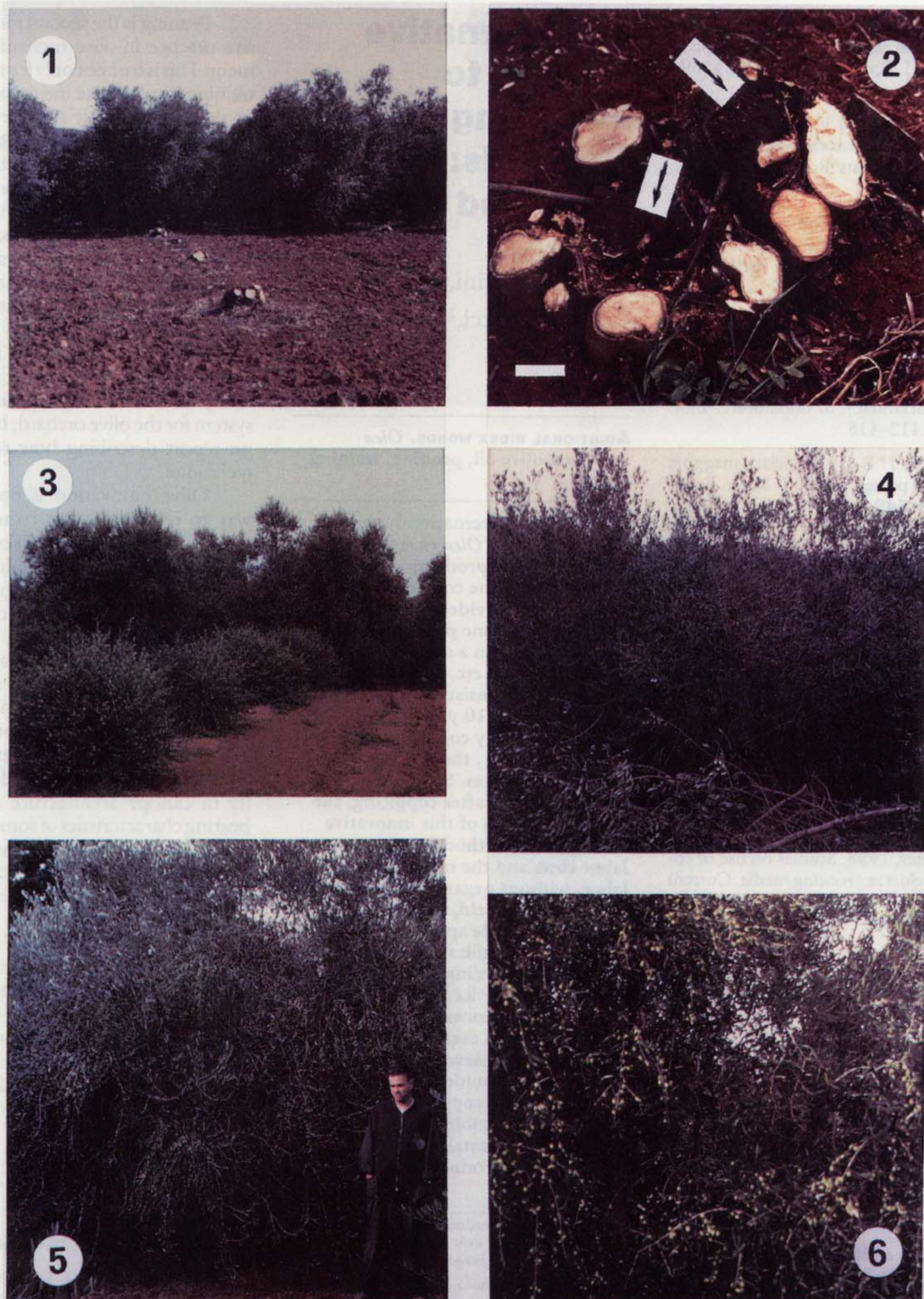
Pruning is the second most expensive practice in olive orchard management. This is true not only for traditional training systems, like the polyconic vase or the full vase, but also for more recently introduced systems like the spindle (monocone). Pruning olive trees often involves drastic cuts to major branches or to the trunk to reconstitute the canopy after severe frost damage (Sibbett, 1994). Olive trees have a high capacity to resprout from the crown and, under most circumstances, resprouting is vigorous and the new canopy becomes productive in 3 to 5 years. Therefore, coppicing (cutting the trunk at ground level) could be a routine management system for the olive orchard, but there is no report describing how to use this technique.

Olive cultivation is costly. One way to reduce costs is to mechanize pruning and harvesting (Fontanazza, 1993), but results are still largely unsatisfactory because of the growth and fruiting characteristics of the tree. The thin, long, flexible shoots, the small size of the fruit, the fruit-bearing habit (fruit borne on 1-year-old shoots on the external shell of the canopy), and the dense foliage all complicate mechanical harvesting (Martin et al., 1994). In addition, the wide variability in canopy architecture and fruit-bearing characteristics of some varieties, including many cultivars renowned for the excellent oil quality (Preziosi et al., 1994), further restrict progress in mechanization.

We describe an alternative method to olive orchard management. The method consists of exploiting the high resprouting capacity of this species after coppicing. This system was developed primarily to minimize pruning costs and simplify orchard management. Preliminary results of a long-term study on the effect of coppicing on tree performance and oil yield have been previously reported (Cantini and Sillari, 1998; Cimato et al., 1990).

Materials and methods

The research was carried out in an orchard at Gavorrano, province of Grosseto, Italy (42°47′25″N, 11°10′40″E), in a typical area for olive cultivation. The climate was typically Mediterranean with an annual rainfall (mean of 20 years) of 840 mm and a drought period during the summer. The soil texture was 55% sand, 30% silt, and 15 % clay with a pH of 6.6.



Figs. 1–6. (1) General view of the coppiced olive orchard. The stumps remaining after the coppicing of trees (performed in the spring) are shown in the foreground. Nine-year old trees, which will be coppiced the following year, are in the background. (2) Close-up view of the stump immediately after coppicing, showing 10-year-old cuts (arrows) and more recent ones. Bar = 5 cm. (3) Olive bushes at the end of the first growing season after coppicing. Sprouts were allowed to grow freely without any pruning. Ten-year-old trees, ready to be coppiced, are shown in the background. (4) Olive bushes at the end of the third growing season after coppicing, when a few sprouts were eliminated in the central part of the canopy. The prunings are shown in the foreground. (5) Eight-year-old trees in full production in the coppiced olive orchard. (6) Fruiting shoots on a 9-year-old tree growing in the coppiced orchard.

Table 1. Summary of pruning practices and time required to manage the olive orchard by coppicing during a 10-year cycle. Time per hectare was calculated considering the planting density of 277 plants/ha.

Year	Pruning practice	Labor (min/plant)	Labor (min/ha)
0	Coppicing	8	222
3	Sprout thinning	6	166
Total per year		14	388
Total of 10 years		14	3878

Olive trees, grafted on seedlings, were planted at a spacing of 6.0 × 6.0 m in Spring 1969. The trees were trained to a three-branched vasebush and pruned every year until 1979. The vasebush is a training system in which the main branches originate at the soil line directly from the crown. The orchard was managed by coppicing beginning in Spring 1980, when it was divided into 10 plots of ≈25 trees each and all trees in one plot were cut off at ground level (≈5 to 10 cm from the point of emergence) with a chainsaw (Figs. 1 and 2). In the following years, coppicing was extended to one additional plot per year until 1989. Every year the plot to be coppiced was selected randomly from those plots of the initial 10 that had not yet been coppiced. In this way, all plots had been coppiced once at the end of the 10-year cycle. In March 1990, the plot first coppiced in 1980 was coppiced again to begin a second cycle of coppicing. As a result of coppicing, the orchard consisted of unevenly aged plots. An adjacent vasebush orchard (planting density 6 × 6 m) was pruned using a standard technique as the control. Standard pruning consisted of annual renewal of fruit wood by selective elimination of ≈25% of the fruiting shoots. Pesticide application, weed control, and fertilization were performed similarly in the coppiced system and the vasebush orchard according to standard commercial practice.

Fruit yield was determined for each plot over the 17-year period. Yields per hectare of the coppiced orchard and the control were compared during 1989–96. Comparisons were not made before 1989 because not all plots had been coppiced at least once. Oil yield was determined on 1 kg of fresh fruit by extraction with tetrachloroethylene using a Foss-let 15310 (Foss-Electric, Hillerød, Denmark). Alternate bearing was evaluated using the indices reported by Monselise and Goldschmidt (1982). The intensity index (I) was calculated using the following equation:

$$I = \frac{1}{n-1}\left[\frac{a_2 - a_1}{a_2 + a_1} + \frac{a_3 - a_2}{a_3 + a_2} + \frac{a_{n+1} - a_n}{a_{n+1} + a_n}\right]$$

where n = the number of years and $a_1, a_2, a_3, \ldots a_{n-1}, a_n$ = yield in successive years. The biennality index (B) was calculated by dividing the pairs of successive years where trends of increase or decrease in yield are reversed by (n – 1); B ranges from 100% full to 0% lack of biennality (Monselise and Goldschmidt, 1982).

Results and discussion

Trees were coppiced no earlier than budbreak to minimize the risks of damage by spring frosts, which occasionally occur in the study area. Olive trees are seriously damaged by –5 °C at budbreak (Loussert and Brousse, 1978). The probability of occurrence of temperatures below this threshold should be considered in deciding the timing of coppicing, since the tissues resprouting after the cut are more tender and vulnerable to freezing temperatures than tissues of mature plants. Coppicing may be performed earlier in warmer zones, where frosts are less common.

All the sprouts from the stump were allowed to grow freely without any pruning until the third year after coppicing, when four to ten sprouts, located in the central part of the bushy canopy, were eliminated to increase light penetration (Figs. 3 and 4). Self-thinning of sprouts occurred naturally after coppicing; the average number of sprouts per plant decreased from ≈360 the first year to 40 the third. The subsequent elimination of sprouts in the third year reduced their number by 10% to 25%.

The time required for coppicing was ≈8 min/plant and for thinning sprouts was 6 min/plant (Table 1). No pruning was done the first and second year after coppicing or from the fourth to the tenth year. Therefore, the coppiced system required 14 min/plant of unskillful labor over the 10-year cycle, or 6.5 $h \cdot ha^{-1} \cdot year^{-1}$ (Table 1). This value is much lower than the time needed to prune olive trees according to standard techniques. Standard pruning practice for either the polyconic vase or the vasebush requires a minimum of 17 min/plant per year (Cantini and Sillari, 1998) corresponding to 170 min/plant or 780 $h \cdot ha^{-1}$ (assuming a planting density of 277 trees/ha) over the 10-year period. Note that pruning the coppiced system is still cheaper than pruning recently introduced systems better suited for mechanical harvesting; for instance, the minimum time needed to prune a monocone tree is 15 min in a mature olive orchard.

The onset of fruit production occurred the third year after coppicing in all plots; production per plant increased up to the seventh or eighth year, when it started to decline. The fruit-bearing habit of shoots and trees was similar to that observed for other training systems (Figs. 5 and 6). The coppiced orchard produced 91% of the fruit yield of the control during 1989–96 (Table 2) and oil yield was unaffected by coppicing. These yields were typical of nonirrigated olive trees growing in the same area and were above the average yields of olive groves in Tuscany.

Coppicing also seemed to reduce alternate bearing. The intensity index (I) and the relative percentage (RP) indicated that alternate bearing was less evident in the coppiced system than in

Table 2. Fruit yield and indices of alternate bearing for the coppiced and the standard olive orchard (three-branch vasebush) during 1989–96. The relative percentage index (RP) indicates the minimum yearly yield as a percentage of maximum yearly yield, the intensity index (I) indicates the intensity of deviation in yield in successive years, and the biennality index (B) the percentage of occasions where an increase in yield is followed by a decrease or vice versa.

	Fruit yield ($t \cdot ha^{-1}$)		Alternate bearing index (%)		
System	Total	Avg	RP	I	B
Coppiced	36.520	4.565	40	28	66
Vasebush	40.050	5.006	12	53	66

the vasebush orchard (Table 2). The biennality index (B), which is the least sensitive to the amplitude of yield fluctuations, was the same for both management systems (Table 2). There were no major effects of coppicing on oil quality, nutritional status of the tree, or disease or pest control (data not shown). Patterns of vegetative growth and fruit development were also unaffected by coppicing. Tree size and yield per tree were relatively uniform within each plot of the coppiced orchard, and variability in vegetative and reproductive parameters was not significantly different from that observed in the control orchard.

The coppicing system can be adapted to most cultural situations and does not require changes in management of the grove or additional costs for purchase or adaptation of machinery. This latter point makes the coppiced system suitable for areas of traditional culture characterized by old trees, obsolete training systems, or small farms. Coppicing is sustainable, since no major problems have arisen in this orchard for 17 years and on trees growing in other orchards that have been coppiced three times. This method can also be used to rejuvenate old trees, thus increasing productivity of obsolete groves. As a result, managing the olive orchard by coppicing has the following advantages: a) reduced labor costs for pruning; b) no skilled labor required; c) low cost implementation; d) attenuation of alternate bearing; e) increased productivity of old trees; and f) control of tree size, which facilitates management of the tree from the ground. The coppiced wood may represent an additional source of income in some areas.

The main disadvantage appears to be the multiple trunks, requiring several attachments for mechanical harvest.

The 10-year periodicity for coppicing should not be considered fixed and should be adapted to different pedoclimatic conditions. In our study area, the optimal duration of the coppiced cycle was estimated at 8 to 9 years based on observations carried out for 17 years; in more fertile soils or under irrigated conditions the duration of the cycle might be extended to >10 years.

In conclusion, the coppiced management system represents an alternative method to olive orchard management because it yields higher revenues than traditional training systems without negative effects on disease and pest control or tree longevity. This system proved sustainable in the long run and compatible with most types of oliviculture.

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