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Increased Yield in the Olive with Putrescine Treatment

Eddo Rugini[1] and Massimo Mencuccini[1]

C.N.R. Centro di Studio per la Olivicoltura, Borgo XX Giugno, Perugia 06100, Italy

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Abstract. Aqueous solutions of putrescine and putrescine dichloride were sprayed on flowers and fruit of self-incompatible olive (*Olea europaea* L.) 'Leccino' and 'Pendolino'. Both diamine formulas increased fruit-set and yield when applied on flowers before anthesis ('Pendolino') and at full bloom ('Leccino'), but they slightly decreased fresh fruit weight. Putrescine dichloride was more effective than putrescine base, stimulating fruit-set with 5×10^{-2} M solution compared to 5×10^{-1} M to 1 M of putrescine base.

Fig. 1. Effects of putrescine base concentrations applied before anthesis on 'Pendolino' fruit-set, 1982.

Low productivity in the olive results from very low fruit-set and subsequent fruit abscission. Various attempts have been made to increase fruit-set and decrease fruit abscission with auxins (6), nitrogenous products (9) and GA₃ or BA (13) but with rather disappointing results. Field use of growth regulators has resulted in variable response because of environmental variation and lack of knowledge about penetrating capacity and the physiological mechanisms regulating abscission. It is known, for example, that abscission is related to the emission of ethylene by the tissues (1) and that ethylene has the same precursor as the polyamines, S-Adenosylmethionine (2). Whereas the former promotes senescence (11), the polyamine retards this process (7). Furthermore, polyamine treatment inhibits ethylene biosynthesis in apple fruit slices and protoplasts (4). It is uncertain whether the polyamine response is direct or indirect. In fact, polyamines inhibit the development of RNAase and protease activity (3, 12), increase RNA synthesis and cell division in *Helianthus tuberosus* L. (5) and induce DNA synthesis (10).

On the basis of these considerations, we tested one of the polyamines, putrescine, in 2 different formulations in an attempt to increase fruit-set and decrease fruit abscission. In 1982, treatments were applied on the flowers of 2 self-incompatible cultivars

(Pendolino and Leccino) and on the fruit of the 'Leccino'. An aqueous solution of putrescine (1,4 diaminobutane) at pH 12 and putrescine dichloride (1,4 diaminobutane dichloride) (Merck) at pH 7 plus 0.01% Tween 80, as wetting agent, was sprayed until runoff at concentrations of 5×10^{-4} to 1 M on flowers and on fruit.

Tests were carried out on uniform 12-year-old trees, vase-trained and grown in a non-irrigated orchard. Ten one-year-old fruit bearing shoots, uniform in vigour and average number of inflorescences (about 60, with about 14 flowers each or with an average of 25 fruit when treatments were carried out after full bloom), were labelled for each concentration of each putrescine formula and control. The 10 shoots were distributed on 5 trees (2 per tree). A total number of 20 trees was selected for the experiments: a) five trees of 'Pendolino' were used to test putrescine base applied on flowers before anthesis (0.5 to 1% of open flowers); b) five trees of 'Leccino' to test both putrescine base and dichloride, applying them on flowers at full bloom; c) five trees of 'Leccino' to test both putrescine formulas applied on fruit at 4 weeks after full bloom in an attempt to decrease fruitlet-drop; and d) five trees of 'Leccino' to test both putrescine formulas on fruit at 20 weeks after full bloom, when the epicarp was completely black, in an attempt to decrease preharvest drop. Control shoots, just as in the other treatments, were distributed on the same trees and sprayed with H_2O and wetting agent.

In 1983, on the basis of the results of the previous year, treatments were repeated only on 'Leccino' at full bloom with putrescine
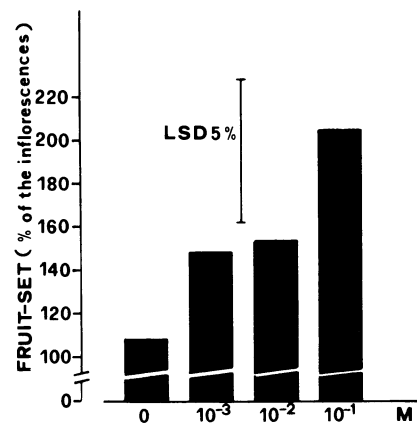
base (see Fig. 2B for concentrations), using the same experimental procedure as the previous year. Furthermore, since, in the previous year, putrescine base was found to cause immediate necrosis of the stigma and styles, NaOH (3×10^{-1} M) solution also was applied to cause the same damage. For this experiment 10 shoots, distributed among the 5 trees used for putrescine base and control, were used. Data on fruit-set percentage (percentage of the fruit set, referred to the number of inflorescences) were collected 3 weeks after treatments. Then, in order to determine relative fruit abscission in experiments carried out on flowers and on the fruit at 4 weeks after full bloom, the fruit still remaining at 10, 14, and 18 weeks were counted. Olives were harvested at 18 weeks after full bloom, when the epicarp was almost completely black, except for those from the last treat-
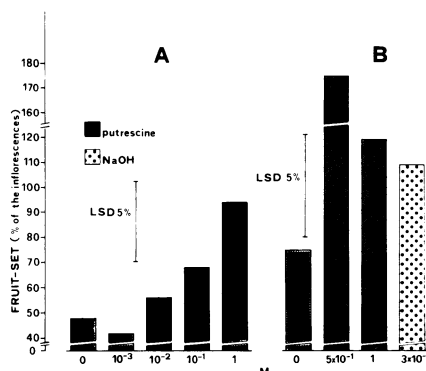
Fig. 2. Effect of putrescine base and NaOH concentrations applied at full bloom on 'Leccino' fruit-set; **A** = 1982, **B** = 1983.
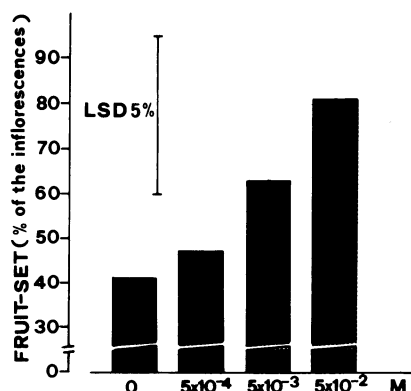
Fig. 3. Effect of putrescine dichloride concentrations applied at full bloom on 'Leccino' fruit-set, 1982.

ment (at 20 weeks after full bloom) which were harvested 4 weeks after treatment. At harvest, detachment force, average fresh weight, dry weight and oil percentage were determined in 200 fruit. The data were analyzed by ANOVA.

Putrescine base at the highest concentrations (10^{-1} to 1 M) caused immediate necrosis of all stigmas and styles when applied at full bloom on 'Leccino'. At these high concentrations, however, putrescine base increased fruit-set about 2 times on 'Pendolino' at 10^{-1} M in 1982 (Fig. 1) and on 'Leccino' at 1 M in 1982, and from 5×10^{-1} to 1 M in 1983 (Fig. 2A, 2B). Putrescine dichloride increased fruit-set on 'Leccino' about 2 times in 1982, when applied at full bloom at the highest concentration (5×10^{-2} M) (Fig. 3). This positive effect at 5×10^{-2} M contrasts with the high concentrations of putrescine base needed for an equal effect (Fig. 1 and 2). Our results are contrary to the independent work of Costa and Bagni (8) on apple. They obtained an increase in fruit-set with
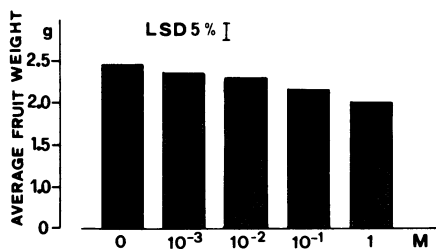

Fig. 4. Effect of putrescine base concentrations applied at full bloom on 'Leccino' average fruit weight, 1982.

very low concentrations of putrescine dichloride (10^{-6} and 10^{-5} M).

Both putrescine base and putrescine dichloride slightly reduced average fresh fruit weight of 'Pendolino' (1982) and 'Leccino' (1982 and 1983). The data for putrescine base treatment on 'Leccino' in 1982 are shown in Figure 4. This decrease in fruit size is not surprising as these cultivars have low productivity potential, and even a slight increase in fruit number results in a decrease in fruit weight. However, the decrease in our experiments had little effect on yield increase.

When applied either before anthesis ('Pendolino') or at full bloom ('Leccino'), neither formulation affected dry weight, detachment force, or oil percentage. None of these parameters was affected by either formulation when applied to 'Leccino' at 4 weeks or 20 weeks after full bloom, nor was there any effect on fresh weight from application after full bloom. Relative fruit abscission was not modified by any of the treatments applied to flowers. The quantity of fruit harvested was proportional to the initial fruit-set percentages in all treatments on both cultivars. In spite of its antiethylene characteristics (4), neither purtrescine formulation was effective in reducing fruit abscission when sprayed on the fruit. This lack of effectiveness is in agreement with the results of previous tests on olive with the strong antiethylene substance, $AgNO_3$. $AgNO_3$ was able only to delay fruit blackening (Rugini, unpublished data). Fruit blackening also was delayed in olives treated with high putrescine concentrations, but we feel this reflects the high number of fruit. Heavy fruit-set is known to delay fruit blackening in olive. Apart from stigma and stylar necrosis, 3×10^{-1} M NaOH had no statistically significant effect, either on fruit-set (Fig. 2B) or on other parameters measured.

Our results show that both putrescine formulations, when applied to flowers, can increase fruit-set with only a very slight decrease in fresh fruit weight. We feel that further research is warranted, because putrescine is the 1st product that seems capable of increasing yield in the olive. Experiments are in progress to determine treatment timing for maximum effect and economic use. It also would be of interest to try L-arginine, because it is known to be metabolized immediately into polyamines (14).

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