Improving Ethephon’s Effect on Olive Fruit Abscission by Glycerine

Yosef Ben-Tal
Institute of Horticulture, Agricultural Research Organization, The Volcani Center, Bet Dagan, Israel

Abstract. Ethephon solutions at pH 7 have been used for several years to facilitate mechanical harvesting of olive (Olea europaea L.) fruits in Israel, but results were not always satisfactory, especially in the more arid regions of the country. Previous studies indicated that occasional failures were due to hot and dry weather conditions that caused rapid drying of the sprayed solution, resulting in inadequate uptake of e"ephon into the plant tissues. Addition of 1% glycerine to the solution did not enhance e"ephon uptake, but delayed evaporation and drying of the solution sprayed on ‘Manzanillo’ olive trees. Extended presence of e"ephon as a liquid solution allowed more of it to penetrate the tissue, as was indicated by a 345% increase in ethylene evolved from leaves. Prolonged presence of the solution on the sprayed trees also reduced fruit removal force and improved fruit abscission under similar climatic conditions. Chemical name used: (2-chloroethyl)phosphonic acid (e"ephon).

Most of the olives grown in the world are harvested by hand-picking. An irrigated olive grove may produce over 20 t·ha⁻¹ during “on” years. An average fruit weighs 4.5 g; therefore, more than 4.5 million fruit have to be picked in order to complete harvesting of a single hectare of olive trees.

The fruit removal force (FRF) of green mature table olives varies among cultivars between 200 and 900 g. The large fruit have thick stems and require great force to be removed (10). It was discovered that ethylene released from e"ephon could cause fruit abscission in olives (6). Ethylene treatments caused cell plasmolysis in segments of fruit pedicels, therefore reducing the FRF required to achieve fruit abscission (12). The number of cells plasmolyzed was concentration-dependent, and increased ethephon concentrations also resulted in severe leaf drop. On the other hand, failures to achieve reasonable fruit abscission were observed in some field experiments. Therefore, transition from laboratory work to practical mechanical olive harvesting introduced two major problems: 1) severe leaf drop and 2) occasional failures in achieving sufficient fruit drop after e"ephon treatments.

The first major problem was solved by adjusting the pH of the e"ephon solution (2). Leaf drop occurred when ethylene was released over extended periods of time in treated trees. Fruit drop resulted from a short exposure to high levels of ethylene (4). As the rate of ethylene released from e"ephon was pH-dependent, pH 7-adjusted e"ephon released ethylene at an adequate rate to affect mainly fruit abscission (2).

The reason for occasional failures to achieve fruit abscission was insufficient ethylene in the pedicels to cause enough cells to plasmolyze (Y.B.-T., unpublished data). Failures occurred mainly in hot, dry regions of Israel, or when e"ephon treatments were made during hot, dry days. Studies indicated that both temperature and relative humidity were major factors controlling the amount of e"ephon uptake by the plant tissue, because e"ephon was degraded before being absorbed (3, 8, 9). These studies helped to establish the preferred climatic conditions under which e"ephon treatments will be most effective. However, the problem is that, in many regions of the country, suitable climatic conditions (<22°C and >85% RH) rarely occur during the harvesting season (September–November). Quite often, treatments are made under less than favorable conditions, and the spray solution dries before sufficient quantities of e"ephon penetrate the fruit stem, and fruit do not drop.

The purpose of this work was to extend the period of time that the sprayed trees remained wet, prolonging the period of e"ephon uptake into the fruit stems. Several additives were tested to retard drying. Some were effective but could not be used commercially because they are not registered or are too expensive for agricultural practices. The only chemical that delayed drying and was commercially acceptable was glycerine.

Determinations of ethylene evolved were made as described previously (9) with minor

Received for publication 13 Oct. 1986. Contribution no. 1805-E, 1986 series. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement solely to indicate this fact.
Table 1. Correlation between fruit removal force (FRF) of ‘Manzanillo’ olive fruit and ethylene evolved from leaves.  

<table>
<thead>
<tr>
<th>Days after spray</th>
<th>FRF (g)</th>
<th>Ethylene (nl · g⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>E + G</td>
<td>E</td>
</tr>
<tr>
<td>0</td>
<td>367 ± 13.3</td>
<td>367 ± 13.3</td>
</tr>
<tr>
<td>1</td>
<td>381 ± 14.7</td>
<td>349 ± 18.1</td>
</tr>
<tr>
<td>2</td>
<td>306 ± 9.8</td>
<td>317 ± 11.4</td>
</tr>
<tr>
<td>3</td>
<td>138 ± 8.2</td>
<td>194 ± 9.3</td>
</tr>
<tr>
<td>4</td>
<td>72 ± 6.1</td>
<td>106 ± 7.0</td>
</tr>
<tr>
<td>5</td>
<td>37 ± 5.7</td>
<td>79 ± 6.6</td>
</tr>
</tbody>
</table>

*Trees were sprayed with pH 7-adjusted 1250 mg-liter⁻¹ ethephon (E) as above, including 1% glycerine (E + G) or 1% glycerine only (control). Fifty fruits were detached from each of four trees. Ten replications of 20 leaves were taken from each tree to determine the amount of ethylene evolved. Values are means of four trees per treatment ± SE.

Table 2. Fruit removal force (FRF) values of ‘Manzanillo’ olive fruit 6 days after spraying with various combinations of ethephon and glycerine.

<table>
<thead>
<tr>
<th>Ethephon concn. (mg-liter⁻¹)</th>
<th>Glycerine concn. (%)</th>
<th>FRF (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.0</td>
<td>471 ± 20.2</td>
</tr>
<tr>
<td>1250</td>
<td>0</td>
<td>244 ± 22.6</td>
</tr>
<tr>
<td>1250</td>
<td>0.5</td>
<td>175 ± 14.1</td>
</tr>
<tr>
<td>1250</td>
<td>1.0</td>
<td>127 ± 13.7</td>
</tr>
</tbody>
</table>

*Fifty fruit were detached at random from each tree with the aid of a dynamometer. Results are means of values from four trees for each treatment ± SE.

The trees stayed wet until morning, especially with the aid of a Chatillon dynamometer.

Fruit removal force was determined by detaching 50 fruit at random from each of four trees per treatment with the aid of a Chatillon dynamometer.

Fruiting olive branches on three trees were sprayed at 9:00 AM with 1250 mg-liter⁻¹ ethephon solution adjusted to pH 7, either with or without 1% glycerine. The branches were allowed to dry for 2 hr and then cut and brought into the lab. They were washed thoroughly to remove any ethephon residue. The leaves were removed, divided into groups of 20 leaves, weighed, and placed in 35-ml vials that were tightly sealed and placed for 4 hr in an oven to allow complete release of the ethylene from the sprayed leaves. After 4 hr, the vials were removed and 1-ml samples of the interior atmosphere of the vials were injected into a GC to measure ethylene concentrations. The amounts of ethylene evolved from leaves sprayed with glycerine containing ethephon in two different experiments were 2.3 and 4.6 times larger than from branches sprayed with ethephon only (Fig. 1). The difference between the two experiments results from differences of the climatic conditions that prevailed during the time branches were sprayed and drying. The high temperature and low humidity that prevailed during the second experiment accelerated breakthrough of the ethephon and, therefore, ethephon accumulation in the leaves was reduced.

In order to rule out the possibility that glycerine enhanced the uptake and/or penetration of ethephon, olive branches were immersed in 1250 mg-liter⁻¹ ethephon solutions (pH 7) with or without 1% glycerine for 10, 20, 30, 60, or 120 min. After each period of time, 200 leaves were removed from each solution, thoroughly washed, divided into groups of 20, and treated as described previously. There were no differences in the amounts of ethylene evolved from leaves immersed in ethephon solutions with or without glycerine for similar periods of time (Fig. 2). The only factor that controlled uptake was the period of time during which the branches were soaked in the ethephon solution. The presence of glycerine did not enhance ethephon uptake.

Field experiments were performed in which ‘Manzanillo’ olive trees were sprayed at 10:00 PM, when the temperature was 14°C and pH was 93%, with 1250 mg-liter⁻¹ ethephon solutions (pH 7) with or without 1% glycerine. The trees stayed wet until morning, especially those sprayed with glycerine. The FRF values for olive fruit from trees treated with ethephon solutions containing glycerine were reduced more than those for fruit from trees treated with ethephon plus glycerine (Table 1).

A reduced concentration of glycerine (0.5%) in the spray solution also was checked and had a smaller effect on reducing FRF than that achieved with 1% glycerine in the spray solution (Table 2).

From previous experience it was determined that FRF values ≤150 g are enough to achieve good fruit drop by tree shaking. Our assumption is that ≈1500 nl · g⁻¹ of ethylene evolved from the sprayed leaves is sufficient to achieve good fruit drop. This goal is obtained only when the sprayed trees remain wet for 2 to 3 hr. It also explains why the levels of ethylene evolved are much larger in the field experiment (Table 1) than in the laboratory experiments (Figs. 1 and 2).

Mechanical harvesting of fruit has been studied for cherries (5), citrus (11, 13), macadamia nuts (7), and olives (1, 6). Major problems limiting the use of mechanical harvesting are insufficient uptake of ethylene-releasing compounds into plant tissue and having them selectively influencing fruit but not leaf abscission. Introduction of glycerine is another step in improving uptake of ethephon into plant tissue, especially in hot, dry climates, which prevail almost everywhere olives are grown.

**Literature Cited**

Performance of 'Swiss Bartlett' Pear on Several Old Home x Farmingdale Quince and Seedling Rootstocks in British Columbia

L.G. Denby and M. Meheriuk
Agriculture Canada Research Station, Summerland, B.C. V0H 1ZO, Canada

Abstract. 'Swiss Bartlett' pear (Pyrus communis L.) was evaluated on Old Home x Farmingdale (OH x F) rootstocks 34, 69, 87, 130, 230, 333, and 515; EM Quince A; and Lepage C Quince, and Old Home and Bartlett seedlings planted in 1974 at 2.4 x 4.8 m. All trees on OH x F 51 were winter-killed within 2 years of planting and thus could not be evaluated. Marketable yields from 1975 to 1979 inclusive showed OH x F 87 to be the most precocious rootstock, followed by OH x F 515, 34, and 69. Yields as recorded for the trees in their 5th and 10th year of production were higher for OH x F 87, OH x F 69, EM Quince A, and Lepage C Quince than for most of the other rootstocks.

Clonal rootstocks selected from Old Home x Farmingdale crosses (1) have generated considerable interest as potential rootstocks for pear plantings in the Pacific Northwest (2-5). Westwood et al. (5) indicated a wide range of vigor among these clonal rootstocks, and trees grown on these rootstocks tended to be uniform in size, resistant to winter injury and fire blight, and moderately tolerant to crown rot. A subsequent report (3) outlined the response of several pear cultivars on a number of clonal and seedling rootstocks grown in three locations in Oregon. Twelve clonal OH x F selections were found suitable for general use. Preliminary results by Denby and Meheriuk (2) showed higher yields and tree efficiency with 'Swiss Bartlett' on OH x F 87 than on other OH x F or seedling rootstocks. Tree performance during a 10-year period has been completed in the latter study, and this report presents the results obtained for the period 1975 through 1984.

Rooted cuttings of the OH x F clones 34, 51, 69, 87, 130, 230, 333, and 515; EM Quince A; and Lepage C Quince were supplied by Daybreak Nursery, Forest Grove, Ore. Bartlett and Old Home seedlings (from seeds) were grown at Summerland, B.C. All were field-grafted in Spring 1974. The trial consisted of four adjacent rows, each subdivided into three consecutive plots. Each plot within each row contained single trees of each of the 12 rootstocks arranged in a systematic manner (a total of 12 replications per rootstock). The trees were planted at 2.4 x 4.8 m in soil that varied from sandy loam to heavy silt loam (848 trees/ha).

Trees were trained as a central leader. Vegetation within the tree row was controlled by 1,1'-dimethyl-4,4'-bipyridinium salts (paraquat). Fertilizer (34N-0P-0K) was applied at 225 kg ha^{-1} and augmented with foliar sprays of urea when required. Trees were permitted to bear fruit in the second year. Thinning was done by hand, and fruit was spaced to 20 cm. Individual tree yields were recorded yearly and fruit was classified as culls if <57 mm in diameter. Cumulative marketable yield (total less cullage) for the first 5 years (1975-1979 inclusive) was used as a measure of precocity among the rootstocks.

In the winter of the 5th and 10th years of production, trunk cross-sectional area (cm²), 30 cm above the graft union, was recorded for each tree and used to calculate tree efficiency as cumulative yield, kg/trunk cross-sectional area (cm²), for 1979 and 1984 crop years, respectively.

All data were analyzed by analysis of variance with all sources of variation except that associated with rootstock differences combined in the error term to provide a conservative test in the absence of randomization within plots. However, because of the nature of the planting, other factors such as wind, light, and root exudates may have had some influence on the results. The statistical procedures used does not eliminate these influences, but does reduce the possibility of their being statistically significant.

All trees on OH x F 51 in the trial failed to survive beyond the second year after planting. Surplus trees on this stock as well as 80% of the ungrafted stocks in the nursery also succumbed to winter injury (about -15°C) at ground level.

Precocity of the scion was most evident...