INDUCING ABSCISSION OF OLIVE FRUITS BY SPRAYING WITH ASCORBIC ACID AND IODOACETIC ACID

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MECHANICAL HARVESTING of olive fruits with commercially available tree shakers has not been completely satisfactory because the energy output of such shakers is usually insufficient to readily remove a high percentage of fruit. Specially constructed shakers with a high-energy output have been shown to be able to detach the fruit, however.

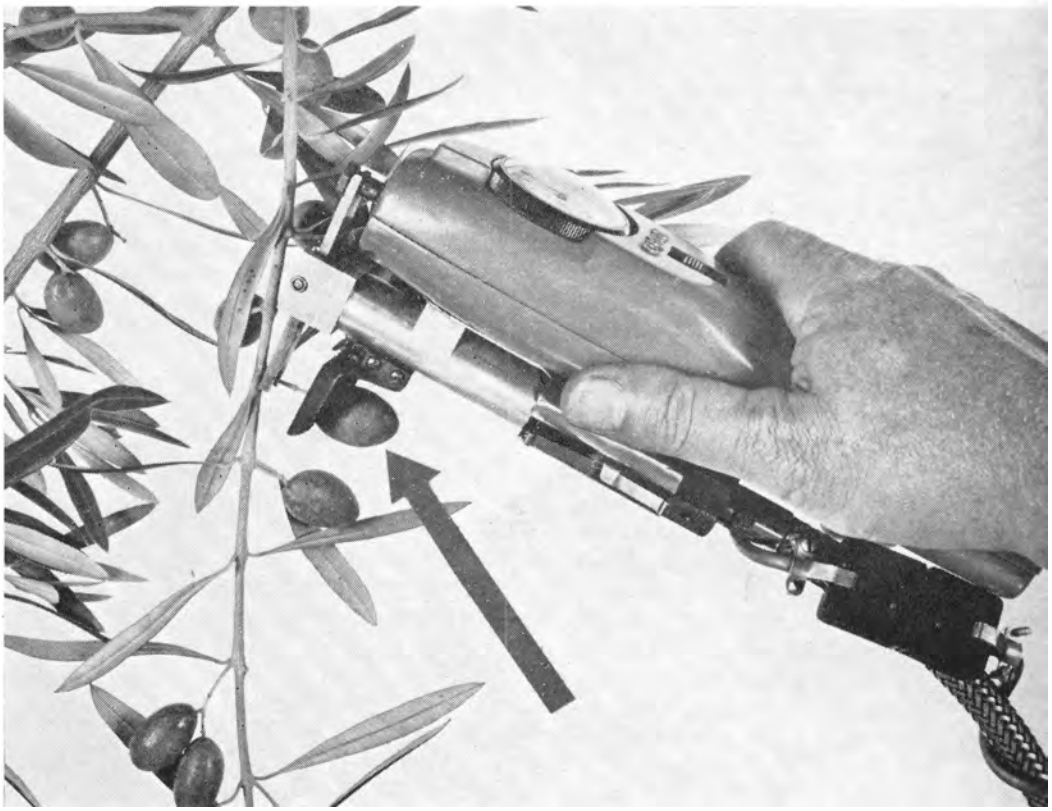
A chemical treatment to reduce the fruit-stem attachment would enable tree shakers to drop the olives more easily onto catching frames, thus permitting mechanizaiton to replace the present laborious method of hand picking. However, such treatments must not cause abscission of the leaves to any appreciable extent—nor leave a toxic residue on the fruit.

Tests with chemicals that might reduce the fruit-stem attachment force were made at Davis and Winters from September 8 to December 15, 1965, using the Manzanillo variety. In all but one trial (see table 1) large, mature orchard trees were used. Each spray application was made to a segment of a tree, amounting to about ⅙ of the total fruiting area. Thus a single tree served for several treatments. Sprays were applied to run-off with a 15-gallon power sprayer. Care was taken to apply sprays so as to avoid drift.

Force measurement

Measurements of the force required to remove olive fruits from shoots were made with a modified Chatillion Model DPP-1000 measuring device (see photo). The power needed for detaching the fruits originated in a motor-generator set (12 v motor—110 v generator) operated from the 12 v battery + generator of a pick-up truck driven into the orchard. From the 110 v generator, a small portable motor strapped to the waist of the operator powered a flexible cable which (by a screw gear arrangement) slowly pulled the fruit from the stem. The force reached at the moment of separation was recorded. This procedure permitted a uniform pull-force to be used throughout all the trials. It also permitted determination of the removal force without prior detachment of shoots, which could introduce errors due to stem and/or fruit desiccation. Retention of the sprayed branches on the tree also permitted observations of any subsequent effects of the sprays. Three measurements were made, at intervals of several days following spraying. Twenty separate measurements

Power-operated pulling device used to detach olive fruits from the shoot and to indicate force, in grams, required to cause separation. Arrow indicates fruit being removed.



were made on each date for each spray application.

In one trial started on November 2, five-year-old fruiting olive trees, growing in 15-gallon containers, were brought into the greenhouse. Four trees were placed in a polyethylene-covered frame into which a continuously running humidifier injected water vapor sufficient to maintain a film of water on the leaves of the trees. Two of these trees were sprayed with ascorbic acid plus glycerine and Vatsol (table 1). Two trees were unsprayed. Two additional trees, also sprayed as mentioned, were placed in the greenhouse with a relative humidity of 50% to 80%—insufficient to maintain any free water on the leaves. Two other, nonsprayed, trees were also placed in the open greenhouse. After spraying, removal-force measurements were made on the fruits of all these trees with the equipment and procedures described.

Eight days after spraying with ascorbic acid plus glycerine, the force required to remove fruits from trees held under the saturated air moisture conditions was less than half that required to remove fruits from unsprayed control trees under the usual greenhouse humidity conditions (see table 1). The attachment of fruits on sprayed trees in the polyethylene-covered frames with the humidifier was sufficiently decreased so that slight handshaking of the branches dropped the fruits. Fruit on trees under the same high-moisture environment, but not sprayed, showed slightly less attachment force than did those on trees under low humidity, but more than those on similar, sprayed trees.

TABLE 1. FORCE IN GRAMS REQUIRED TO REMOVE OLIVE FRUITS FROM STEMS OF TREES IN CONTAINERS IN GREENHOUSE AT TWO DIFFERENT AIR MOISTURE LEVELS (AVERAGE OF 20 FRUITS)

Treatments*	Average force to remove fruits (grams)		
	Nov. 8	Nov. 11	Nov. 18
1 Trees held in polyethylene-covered cage. Humidifier on continuously to provide film of water on leaves. Trees sprayed with ascorbic acid, 3% + glycerine, 3% + Vatsol O. T., 0.1%	341	323	401
2 Same as treatment (1) but no sprays applied	...	686	531
3 Trees placed in greenhouse. Relative humidity 50% to 80%. Trees were sprayed with ascorbic acid, 3%, + glycerine, 3%, + Vatsol O.T., 0.1%	605	575	665
4 Same as treatment (3) but no sprays applied	636	701	620

* Trees placed under differential treatments November 2, 1965. Sprays applied November 3; pull tests November 8, 11, and 18.

Rainy weather

In spray applications to orchard trees November 19, preceded and followed by periods of rainy weather, a reduction in fruit-stem attachment occurred due to ascorbic and iodoacetic acid and related forms. Iodoacetic acid at 150 ppm plus glycerine plus Du Pont WK surfactant caused the greatest reduction in attachment, completely dropping all fruits and leaves. Fruits having an attachment force of 250 grams or less were readily detached with a slight shaking of the branch by hand. Considerable defoliation occurred with many of these treatments. Satisfactory fruit loosening, without excessive defoliation, was obtained using sodium ascorbate (2%) plus Vatsol O. T. (0.2%), as well as with iodoacetic acid (150 ppm) plus glycerine (2%) plus Colloidal R-548 surfactant (0.5%). Glycerine (3%) plus Vatsol (0.2%) caused considerable defoliation but not much loosening of the fruit (see table 2).

The last spray application (December 2) was followed by 0.52 inch of rain on December 10, 11, and 12. Following the rains, a definite reduction in the required removal force occurred with all the materials applied (see table 3).

In comparing the required fruit removal force for various concentrations of ascorbic acid, there was no pronounced difference in the range from 0.125% to 2.0%. Leaf abscission did not occur except at 2.0%. Neither iso-ascorbic acid nor sodium ascorbate (both at 0.5%) was as effective as ascorbic acid in lowering the fruit removal force.

Iodoacetic acid at 150 ppm, while causing a reduction in the fruit removal force, also caused leaf abscission, particularly when in combination with glycerine or when the pH was lowered to 3.5. Maleic hydrazide, at 1.0% plus Du Pont WK surfactant, caused a reduction in fruit removal force but also resulted in heavy leaf abscission.

Dry conditions

Neither ascorbic acid nor iodoacetic acid was effective in stimulating fruit abscission when spray applications were made under relatively dry conditions. In fact, the presence of *free water* on the leaves, either from rains or artificially by humidifiers, was required for these materials to show much activity. Trials with spray additives of various surfactants and humectants failed to disclose any material which would increase the effectiveness of either ascorbic acid or iodoacetic acid under dry conditions.

Studies were also made of the absorption of radioactive ascorbic acid by olive leaves and fruits as influenced by the ambient air moisture. Four six-year-old fruiting Barouni olive trees, grown in containers, were brought into the greenhouse on December 5, 1965. On January 26, 1966, two trees were placed in a polyethylene-covered frame with a humidifier operating so as to provide an accumulation of water on the leaves. The other two trees were set in the same greenhouse, which had a relative humidity of approximately 70%, insufficient for condensation of water on the leaves. One tree in each group was used for fruit absorption determinations and one tree for leaf absorption measurements. Ten similar shoots, each about 30 cm long, were selected on each tree for treatment and sampling. On January 26, leaves and fruits on all 10 branches on each tree were treated with radioactive ascorbic acid.

Leaf extracts

Leaf extracts taken seven days after treatment and extracts of node segments taken six days after treatment from trees under both high and low humidities were used in the separation of three major organic constituents: sugars, organic acids, and amino acids. This was to determine the fate of the absorbed ascorbic acid. Paper chromatography, spray reagent tests, and radioautography were used to separate and identify individual organic acids.

It is evident that under conditions of high ambient air moisture levels, olive leaves absorb more ascorbic acid than under low levels (see graph). In comparison with the leaves, very little was absorbed directly by the fruits, and there was little difference between the amount absorbed under high and low humidity conditions. Maximum absorption by the leaves was found by the seventh day after application.

The radioactivity in the leaves and nodes six and seven days after treatment was present mostly in the organic acids, particularly ascorbic acid, indicating a low rate of biochemical degradation of the absorbed ascorbic acid. The major part of the labeled ascorbic acid entered through the leaves with relatively little uptake occurring in the fruits. The absorption reached a peak seven days after application (see graph), about the time of maximum loosening of the fruit. The processes in operation to cause such a pronounced absorption of the ascorbic acid are not clearly understood. This absorption peak on the seventh day did not occur unless the trees were held under con-

ditions where some free water could exist on the leaf surface. Possibly a partial breakdown of the cuticle occurred, or maintaining the ascorbic acid in an aqueous solution over an extended period of time may have facilitated absorption.

The graphs also show the amount of ascorbic acid absorbed and retained in the nodes subtending the leaves. Since the fruit peduncle is attached at these nodes (axillary to the leaves), the increased internal levels of ascorbic acid following application of this material are of particular significance in accounting for the reduction in the fruit-shoot attachment.

It has long been known that abscission of plant parts, including fruits and leaves, is a correlation effect influenced by auxin. Ascorbic acid is considered to be a plant growth hormone behaving as an auxin antagonist. The antagonistic effect may be brought about by a direct interaction between the native auxin and the oxidation-reduction state of the ascorbic acid system in the regulation of growth.

The work with these materials for loosening olives is still in the experimental stage. They have not had Food and Drug Administration clearance for this purpose and are not registered for use on olives by the Pesticides Regulation Division of the USDA.

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Absorption and retention of radioactivity in olive tissues during a 10-day period after application to leaves as L-ascorbic acid-1-C^{14}. Expressed as μgms. ascorbic acid absorbed per gram dry weight (except for fruits where expressed as μgms. per fruit).

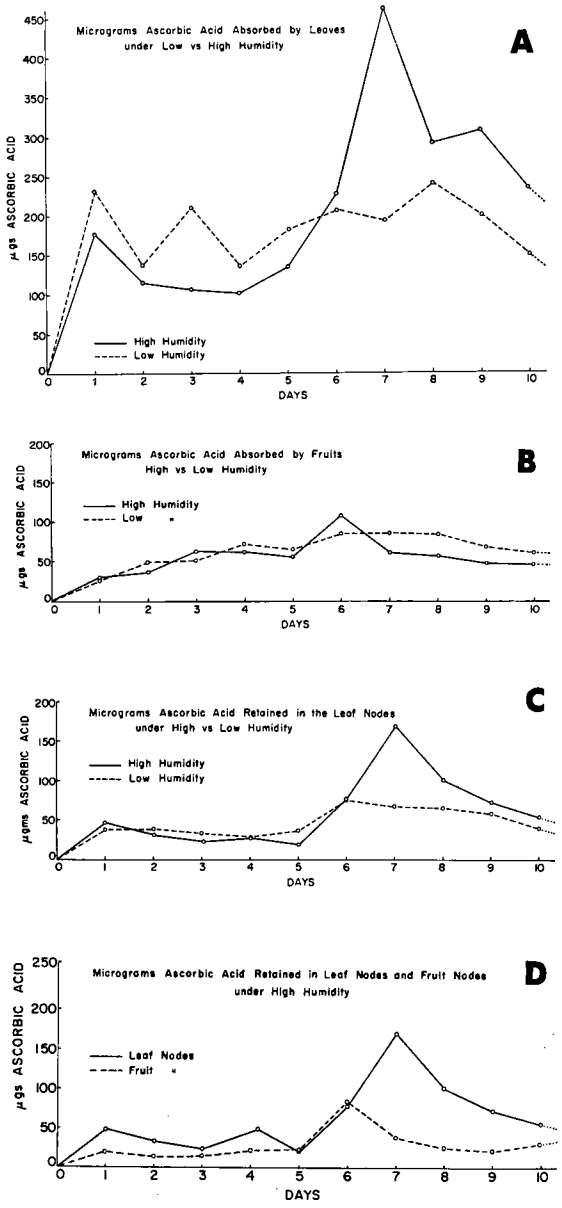

TABLE 2. FORCE IN GRAMS REQUIRED TO REMOVE OLIVE FRUITS FROM STEMS (AVERAGE OF 20 FRUITS)

Spray treatments*	Average force to remove fruits (grams) Nov. 24	Nov. 29	Dec. 3	Defoliation Jan. 29, 1966
Ascorbic acid, 2% + Vatsol O.T., 0.2%	350	350	146	Heavy
Ascorbic acid, 2% + glycerine, 3% + Vatsol O.T., 0.2%	340	309	219	Heavy
Ascorbic acid, 2% + phosphate buffer to pH 3.5 + Vatsol O.T., 0.2%	240	206	295	Heavy
Iso-ascorbic acid, 2% + Vatsol O.T., 0.2%	210	190	238	Heavy
Calcium ascarbate, 2% + Vatsol O.T., 0.2%	442	430	310	None
Sodium ascarbate, 2% + Vatsol O.T., 0.2%	...	329	219	None
Iodoacetic acid, 150 ppm + Vatsol O.T., 0.2%	376	318	278	Moderate
Iodoacetic acid, 150 ppm + glycerine, 2% + Colloidal R-548 surfactant, 0.5%	327	143	267	Slight
Iodoacetic acid, 150 ppm + glycerine, 3% + Vatsal O.T., 0.2%	361	235	252	Heavy
Iodoacetic acid, 150 ppm + glycerine, 2% + Du Pont W.K. surfactant, 0.5%	134	70	0	Heavy (Complete)
Glycerine, 3% + Vatsol O.T., 0.2%	478	413	518	Heavy
Control	560	544	617	None

*Sprays applied November 19, 1965. Rainy period totaled 2.56 inches the preceding six days. Rains on November 23, 24, 25 and 27 totaled 0.58 inch.

TABLE 3. FORCE IN GRAMS REQUIRED TO REMOVE OLIVE FRUITS FROM STEMS (AVERAGE OF 20 FRUITS)

Spray treatments*	Average force to remove fruits (grams) December 7 (before rains)	December 14 (after rains)	Defoliation Jan. 29, 1966
Ascorbic acid + Du Pont W. K. surfactant, 0.5%. Solutions buffered to pH 3.5.			
0.125%	629	228	None; no leaf injury
0.250%	645	278	None; no leaf injury
0.50 %	683	304	None; no leaf injury
1.00 %	583	282	None; slight leaf burn
2.00 %	625	204	Heavy
Iso-ascorbic acid, 0.5% + Du Pont W.K., 0.5%, pH 3.5	609	393	None; no leaf injury
Sodium ascorbate, 0.5% + Du Pont W.K., 0.5%, pH 3.5	575	473	None; no leaf injury
Iodoacetic acid, 150 ppm + Du Pont W.K., 0.5%	645	269	Slight; some tip burning of leaves
Iodoacetic acid, 150 ppm + Du Pont W.K., 0.5%, pH 3.5	556	369	Heavy
Iodacetic acid, 150 ppm + Du Pont W.K., 0.5% + glycerine, 2%	638	219	Heavy
Maleic hydrazide, 1.0% + Du Pont W.K., 0.5%	645	285	Heavy; same tip burn
Du Pont W.K. surfactant 0.5% alone	664	345	None; no leaf injury
Control	618	549	None; no leaf injury

* Sprays applied December 2, 1965. Roin on December 10, 11, and 12 totaled 0.52 inch.