MECHANICAL HARVESTING OF OLIVES

H. T. HARTMANN · W. REED

J. E. WHISLER · K. W. OPITZ

OLIVE GROWERS have had increasing difficulty in getting their crops harvested by conventional hand-picking methods, not only in California but also in Spain and Italy. Over the past 30 years, many University of California workers have participated in research to develop mechanical harvesting of olives in California. Intensive research has also been conducted in Spain and Italy.

Mechanical harvest of immature table olives at a straw-color stage in the fall is more difficult than harvest of the mature, black oil olives in winter, because the immature olives are more tightly attached to the tree. In California, where very little olive oil is produced, the principal interest is in mechanical harvesting of table olives.

Graph 1. Reduction in fruit removal force by spray applications to Manzanillo olive trees of three ethylene-producing chemicals: CHI = cycloheximide; Ethrel (ethephon) = (2 chloroethyl) phosphonic acid; CGA 13586 = 2-chloroethyl-tris-(2-methoxyethoxy)-silane.

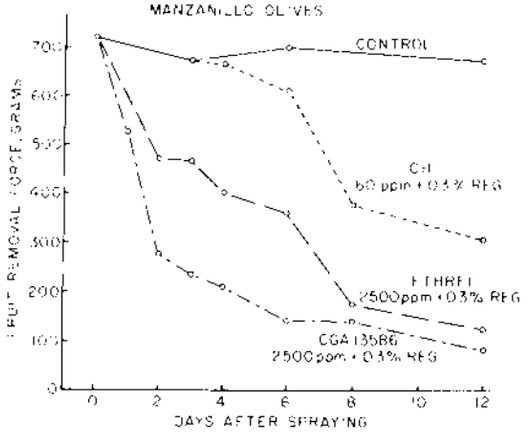


TABLE 1. FRUIT REMOVAL AND LEAF DROP FROM OLIVE TREES IN FOUR CALIFORNIA ORCHARDS FROM MECHANICAL TREE SHAKING WITH AND WITHOUT PRIOR APPLICATION OF AN ABSCISSION-INDUCING SPRAY. AVERAGES OF 10 TREES PER TREATMENT 1974

	Manzanillo (Shimagi orchard, Ivanhoe)	Manzanillo (Pareign orchard, Ivanhoe)	Sevillano (Maywood orchard, Corning)	Mission (Erickson orchard, Orland)
	Per cent fruit removal*,†			
CGA 13586,‡				
1750 ppm	–	86 ab	96 b	–
2000	94 b	92 bc	97 b	92 a
2250	–	97 c	99 b	–
Control (not sprayed)	82 a	79 a	79 a	77 a
	Per cent leaf drop†			
CGA 13586,‡				
1750 ppm	10 b	–	22 a	–
2000	21 c	–	23 a	17 b
2250	15 b	–	25 a	–
Control (not sprayed)	2 a	–	16 a	6 a

* Machine used was Orchard Machinery Company Shock Wave Shaker (with double expanded head, 14–15 star shaking pattern, and using 5 W4-LAB weights).

† Number in columns followed by different letters are significantly different at the 5% level by Duncan's multiple range test.

‡ 2-chloroethyl-tris-(2-methoxyethoxy)-silane (CGA 13586), with Regulaid (0.3%) used as a surfactant.

Early studies by the U.C. Department of Agricultural Engineering and by other agencies showed that mechanical tree shaking was the only feasible method of mass fruit removal. This method must, however, overcome certain inherent difficulties. Olive fruits have a comparatively small mass, are borne on relatively slender, willowy shoots, and, in the case of the green table olives, are tightly attached to the fruit stem. Considerable energy must be applied to the trunk or primary scaffold branches to remove such fruits.

The U.C. Davis Department of Agricultural Engineering developed a tree shaker specifically for olives, which removed about 80% to 85% of the fruits. However, no equipment manufacturer has further developed this prototype machine for commercial use.

Lately, manufacturers of commercial tree-shaking machines have increased the output of their shakers so that acceptable olive removal has been obtained. In four California orchards during 1974 trials, an average of almost 80% of the fruit was removed without the use of a fruit loosening spray (table 1). During the 1973 and 1974 seasons commercial machines harvested an appreciable amount of Sevillano olives for canning in the Corning area.

It became apparent that some type of fruit-loosening chemical sprayed on the tree before shaking would reduce the amount of energy needed and increase the removal percentage. The U.C. Department of Pomology has been studying prospects for the use of such a chemical for a number of years. The first reported success was in 1955 with maleic hydrazide, which caused good olive fruit abscission but only under rainy or foggy conditions with almost 100% relative humidity. This same pattern of activity appeared with a number of other chemicals tried for olive abscission; good results occurred only under conditions of very high humidity. However, such weather patterns are rare in California during October, when most of the table olive harvest takes place.

The commercial development of ethylene-generating chemicals — ethephon (Ethrel) being the first—was a big step forward in obtaining fruit abscission. These growth regulators were active under low humidity conditions and caused virtually no fruit damage. Unfortunately, Ethrel itself caused excessive leaf drop at concentrations high enough to give adequate fruit abscission and had to be abandoned for use on olives.

However, another ethylene-generating compound, 2-chloroethyl-tris (2 methoxyethoxy)-silane (CGA 13586), developed by the CIBA-Geigy Company proved to be more useful as a pre-harvest loosening spray for olives. It satisfac-

TABLE 2. EFFECT OF MECHANICAL HARVEST TREATMENTS ON QUALITY OF FRUIT FROM SPRAYED AND UNSPRAYED BLACK-RIPE PROCESSED OLIVES. SEVILLANO VARIETY. MAYWOOD OLIVE COMPANY. CORNING, CALIFORNIA, 1973

Treatment	Quality Index*	Per Cent Acceptable Fruit†
Mechanically Harvested		
Unsprayed	3.42 a‡	85 a‡
Unsprayed (fruit immediately placed in brine in field)	3.52 b	92 a
Sprayed-CGA 13586 (1500 ppm)	3.53 b	92 a
Sprayed-CGA 13586 (fruit immediately placed in brine in field)	3.50 b	95 a
Hand-picked		
Commercial plant pack	3.20 a	89 a

* An arbitrary figure calculated as follows: 4 = no fruit damage; 3 = light visible scars but no skin breaks; 2 = heavily scarred and bruised but no skin breaks; 1 = unacceptable—skin breaks, cuts, and indentations. The number of fruits in a 100-fruit sample in each category are multiplied by the rating number. These four figures are then added and divided by 100 (no. fruits in sample) to give the quality index for that sample. Three replicate samples were used.

† Sum of two highest categories: (4) undamaged + (3) light visible scars but no skin breaks. (These would be considered commercially usable fruits.)

‡ Numbers in columns followed by different letters are significantly different at the 5% level by Duncan's multiple range test.

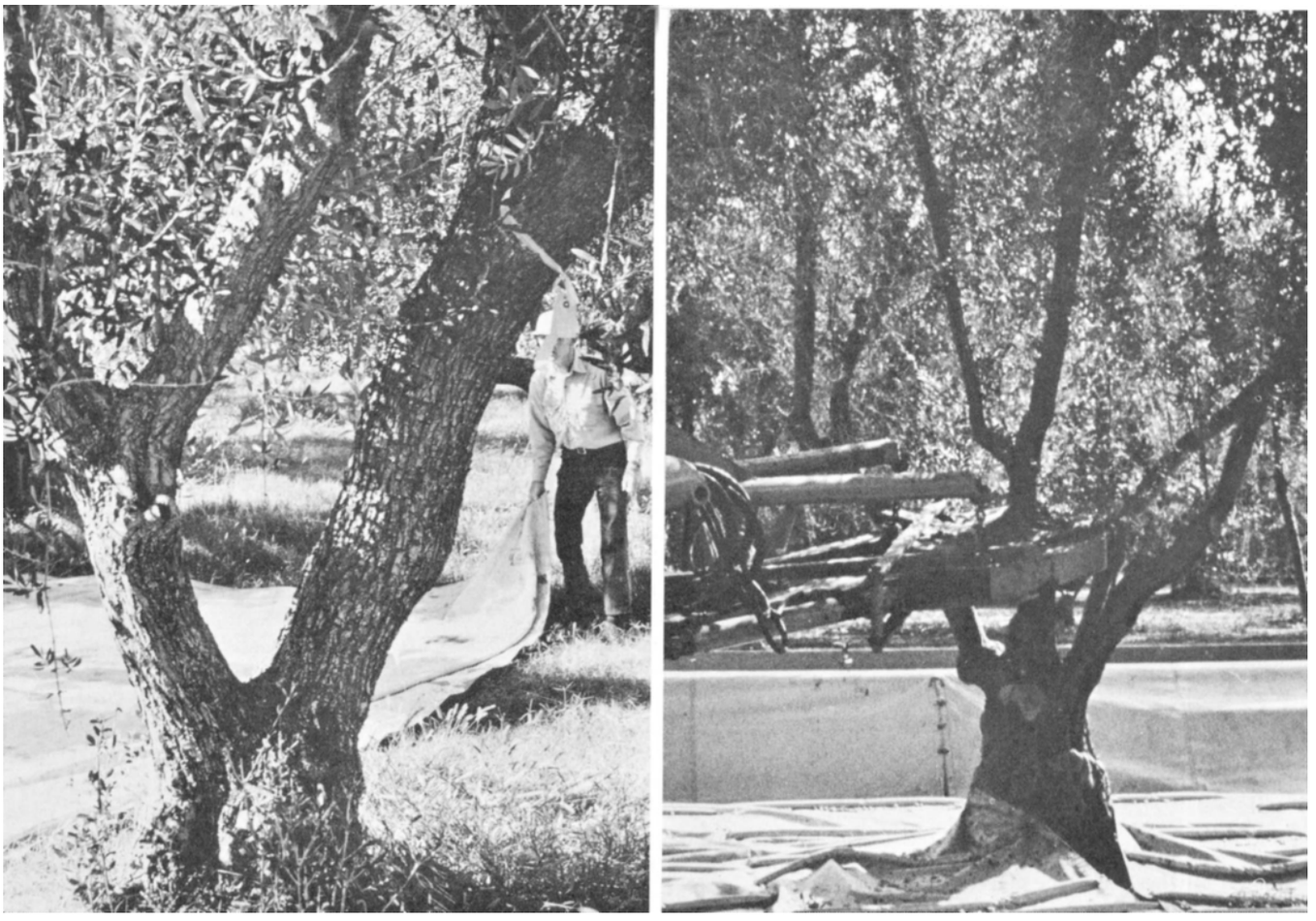


Photo 1. Tree at left is the type that responds well to mechanical tree shaking. The primary scaffold branches are large enough to absorb and transmit the shaker's energy. Scaffold limbs of tree at right are too small for satisfactory mechanical tree shaking.

torily reduced the fruit-removal force required about one week after spraying (graph 1), without excessive leaf drop.

Graph 2 shows the ethylene-releasing pattern of CGA 13586 compared with that of ethephon and of CHI (cyclohexiimide), an abscission-inducing chemical that has been used commercially on citrus. The initial ethylene output of CGA 13586 is much higher than that of ethephon, but not as long lasting. The prolonged higher release of ethylene from leaves sprayed with ethephon may explain why it causes excessive leaf drop.

Residue determinations are now being made for raw and processed table olives and for olive oil from trees sprayed with CGA 13586 to develop data necessary to obtain an EPA registration for use on olives. At present such registration does not exist.

CGA 13586 was used experimentally on olives in 1972 single tree trials at Davis and in 1973 and 1974 in multiple tree trials in Davis and in the principal olive growing areas of the state. Table 1 shows that this chemical sprayed on the trees 7 days before harvest significantly increased fruit removal.

Leaf drop

Leaf drop occurred in all tests with CGA 13586 (table 1), but the amount of defoliation appears to be in the acceptable range. Previous studies have shown that up to 25% leaf removal in October does not reduce flowering the following year. (More than 25% leaf removal reduces flower production in proportion to the number of leaves removed.) Observations and test data show that CGA 13586 applied at harvest in the fall has no physiological effect in either increasing or decreasing flower formation the following spring. Although ethylene hastens ripening of some fruits, in our tests preharvest sprays of these ethylene-generating compounds have not influenced olive maturity.

The ethylene released by CGA 13586 apparently has a direct effect at the abscission zone of the fruit-stem junction. This chemical was applied to different parts of the plant and, after 8 days, the pull force measured. The next to the lowest reading of 171 grams pull force was obtained where only one drop of the chemical was applied in the fruit cavity at the point of attachment with the fruit stem.

During all these trials with mechanical tree shaking equipment in which fruit-loosening chemicals were being tested, it soon became obvious that tree structure strongly influenced fruit removal, often more so than the abscission chemical.

The best fruit removal is from trees whose primary scaffold branches are thick (about six to eight inches in diameter) grow upright, and have the fruit-bearing surface on short twiggy growth around the tops of the scaffolds. In addition, such upright-growing scaffold branches transmit the shaker's energy to considerable heights. Thus, the trees can be allowed to grow to heights that would be impractical for hand-harvesting.

Trees with relatively small primary scaffold branches, but with a single trunk six to ten inches or more in diameter and high enough (three feet) to permit ready attachment of the shaker clamp, can be successfully harvested by trunk-shaking. Trunk-shaking using a wrap-around catching frame can result in a rapid harvesting operation.

In preparing olive trees for mechanical harvesting, it is also necessary to remove all low hanging branches that interfere with the machine operator's vision and to provide room for attaching the shaker clamp to the scaffold branches. No lateral branches lower than six feet should be retained. Trees with many primary scaffold branches should be pruned systematically with the idea of eventually leaving no more than three or four. The fewer attachments the shaker makes for each tree, the more rapid the harvest operation becomes.

Experience shows that, on mature trees, primary scaffold branches smaller than six inches in diameter do not transmit vibration well (photo 1). Trees with secondary scaffold branches that extend horizontally for a distance and then hang downward make fruit removal difficult, even with the use of the loosening chemical, because energy is poorly transmitted through such a structure.

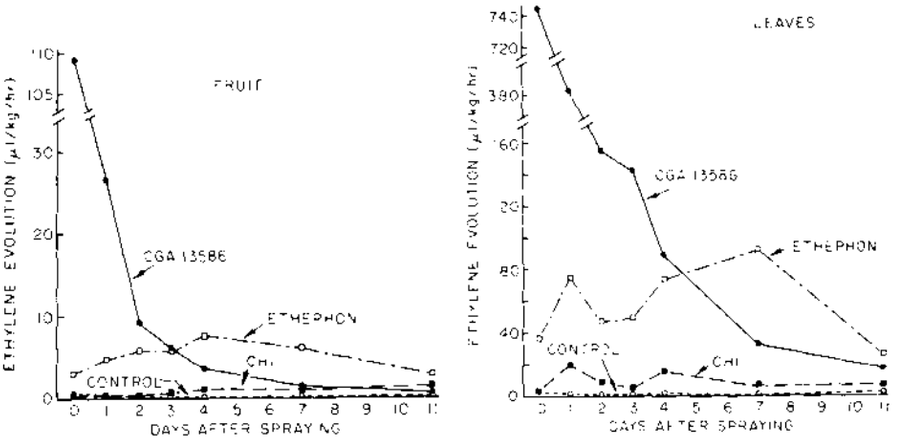
For satisfactory mechanical harvesting of olives by tree shakers, the shaker must be able to move rapidly through the orchard. With limb shakers, the primary scaffold branches should be placed so that the shaker can attach to them from one side of the tree. This obviates the time-consuming need for the machine to circle to the opposite side of the tree to complete the shaker operation.

Mechanized, roll-out, canvas catching frames, commonly used in the prune and almond harvest, may prove satisfactory for catching the olives released by the mechanical shaker. Such an arrangement may consist of two roll-out catching frames used outside adjacent tree rows, with one shaker working the two rows from the inside.

For mechanical harvesting of olives to prove successful, the soil surface must be adequately prepared. Any levees had best be leveled and the ground surface smoothed so the equipment can move easily. Irrigation water should be scheduled so that the soil will be dry enough to bear heavy equipment.

Although harvesting fruits by mechanical methods appears rougher on the fruit than conventional hand-picking, quality of the black-ripe processed product is equal to that of hand-picked fruit. Fruit-quality evaluations over several years during these harvesting trials with olives have confirmed this. Table 2 shows typical results obtained in such fruit-quality evaluations. In this comparison, quality of the mechanically harvested fruit was at least equal to that in the hand-picked commercial pack.

Graph 2. Ethylene output from olive fruits and leaves after spraying with three different ethylene-producing chemicals, CHI, ethephon, and CGA 13586.



H. T. Hartmann is Professor of Pomology, W. Reed is Post-Graduate Research Pomologist, and J. E. Whisler is Staff Research Associate, Department of Pomology, University of California at Davis. K. Opitz is Extension Subtropical Horticulturist, San Joaquin Valley Agricultural Research and Extension Center, Parlier. *This work was supported in part by grants-in-aid from the Olive Administrative Committee, Federal Marketing Order No. 932, and the Agricultural Division, CIBA-Geigy Corp., Greensboro, North Carolina. Mechanical tree-shaking equipment and operator was supplied by the Orchard Machinery Company, Yuba City, California. Messrs. Shimagi, Pareign, Oberti, and Erickson, and the Maywood Olive Co. kindly permitted the use of their orchards for part of the trials. Mr. Elton Develter, Maywood Olive Co., processed the olive samples reported in this study. Lyndon Brown, Joe Osgood, and G. S. Sibbett, Farm Advisors in Kings, Tehama, and Tulare counties, respectively, assisted in field trials.*

Photo 2. Tree shaking equipment in action on a well-prepared tree. Fruit is being caught on a mechanized, roll-out, canvas catching frame.