Effects of Ethephon on Stomata, Ethylene Evolution, and Abscission in Olive (*Olea europaea* L.), cv. Coratina[1]

Claudio Vitagliano[2]
Università di Pisa, Italy

Abstract. Ethephon (2-chloroethylphosphonic acid) at 1500 ppm applied 8 to 15 days before harvest effectively reduced the fruit removal force (FRF) of 'Coratina' olive. Ethylene evolution from fruits and leaves occurred within 1 hour and reached a maximum about 48 hours after application of ethephon. This chemical also enhanced stomatal aperture, suggesting that it might have important implications with respect to CO_2 uptake and transpiration.

A number of recent studies have dealt with the promotion of olive abscission with chemical sprays (3, 6, 7, 8, 9, 11, 13, 16, 18). All of the materials tested (maleic hydrazide, glycerine, ascorbic acid, iodoacetic acid, salicylic acid and ethephon) accelerated fruit abscission, but only under certain ambient conditions (8, 9). Of these materials, ethephon has proven to be the most effective substance in causing olive fruit abscission without promoting excessive leaf drop (4, 10, 17, 18).

We report here some further observations on the use of ethephon to promote abscission of mature olive fruits.

Materials and Methods

Representative branches supporting 700–800 fruits were selected at random on trees of 'Coratina' located in the Tuscan Coastal area in 1972 and 1973. Two branches per tree (12 trees) were sprayed Dec. 4, 1972, approximately 15 days before commercial harvest with 1500 ppm ethephon. In 1973, one branch per tree (12 trees) was sprayed about 12 days before commercial harvest. A similar number of control branches were left untreated. In both years the treatments were applied when fruit removal force (FRF) was about 415 g.

Fruit removal force was determined at weekly intervals until harvest in 1972 on 100 fruits per branch with a "Carpo" dynamometer gauge fitted with a claw. In 1973, FRF measurements were made nearly every day from the time of treatment until harvest.

Fruit samples were collected in 1972 at the time of FRF determinations and analyzed immediately for ethylene evolution by gas chromatography using the method of Blanpied (1). Translocation studies were made by treating single fruits and/or leaves using 1500 ppm ethephon, and analyzing contiguous leaves and fruits for ethylene evolution during the subsequent 24 hours.

The effect of ethephon on stomata apertures was also determined with the collodion technique (5). The number of open and closed stomata was measured at irregular intervals for 15 days (on potted trees in the greenhouse) after treatment with 1500 ppm ethephon. Five leaves from treated and untreated trees were sampled at noon. Stomata were counted in 5 areas per leaf.

Results

Ethephon markedly reduced FRF in 1972 (Table 1), causing a 42% reduction in 7 days and a 54% reduction after 14 days. The wetting agent used showed only insignificant reductions of FRF.

In 1973 ethephon gave a response even more impressive. Measuring the FRF every day (Fig. 1), a reduction in FRF was noted the first day after treatment and the maximum reduction was evident at 3–4 days after treatment. However, a strong wind during the first few days of the experiment caused many of the more mature fruits to drop. The remaining less mature fruits biased the results, giving a small increase in FRF over the remainder of the experiment. No abnormal leaf abscission or pathological effects were apparent in either year.

Ethylene evolution from ethephon-treated fruits was measured in 1972. No ethylene could be detected in untreated fruits. Treated fruits showed a rapid increase in ethylene production 3 to 9 hours after treatment (Fig. 2), with only small increases occurring after that, during the 24 hours in which the experiment was in progress. In a similar experiment (Fig. 3), ethylene evolution reached a maximum after 2 days, and remained approximately constant until the 7th day. At that point a rapid decline in ethylene production began, and continued until the end of the experiment on the 14th day, at which time virtually none could be detected.

The data indicate that the ethephon and/or the ethylene produced from it can be translocated over short distances in olive (Fig. 2). When leaves only were treated with ethephon, ethylene could be detected in the adjacent fruits after 9 hours, though the amount of ethylene was smaller than when ethephon was applied directly to the fruits. No ethylene evolution was detectable from adjacent leaves when only the fruits were treated.

In addition to its effect on ethylene production and FRF, ethephon influenced stomatal aperture (Fig. 4). Treated leaves of 'Coratina' had

Table 1. Abscission effect of ethephon and wetting agent on 'Coratina' mature olive fruits in 1972.

Chemicals and concentrations	Application date	Days after treatment[z]		
		0	7	14
Ethephon 1500 ppm + Irol 0.05%	12/4/72		240.6B	191.9A
Irol 0.05%	"		381.0C	351.7D
Untreated control	—	413.0E	412.9E	407.5E

[z] Means within column and row followed by different letters are significantly different at P = 0.01.

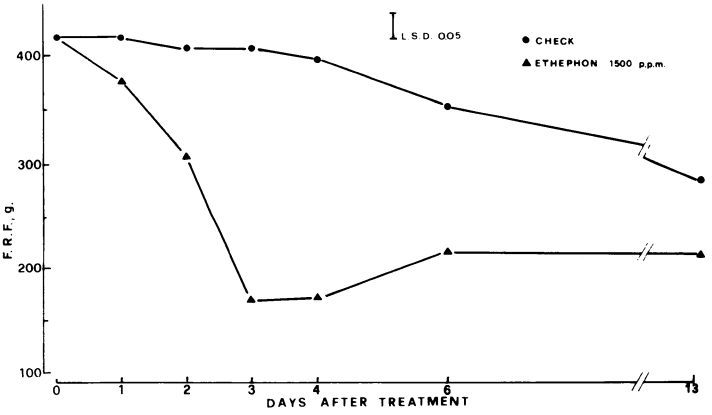

Fig. 1. Effect of ethephon on FRF of mature olive fruits in 1973.

[1] Received for publication October 16, 1974.
[2] Istituto di Coltivazioni Arboree, Pisa, Italy.

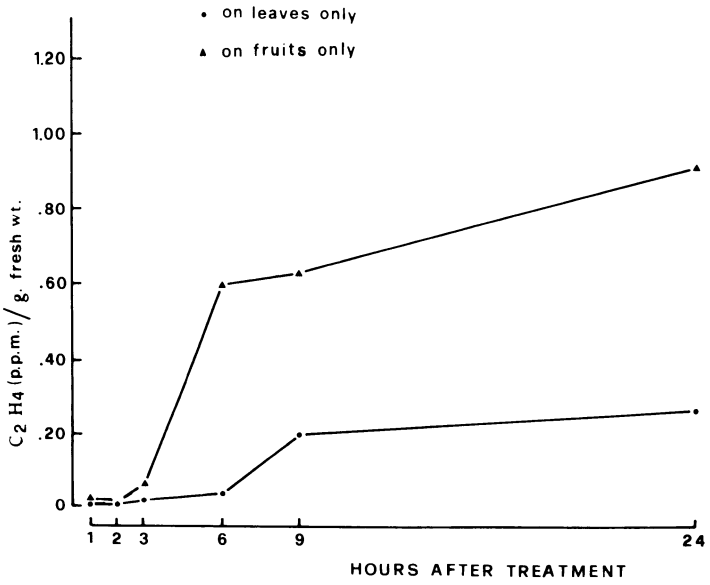

Fig. 2. Ethylene evolution from mature fruits of olive during the 1st 24 hours after treatment as influenced by the site of application of ethephon. Ethephon was applied to adjacent leaves only and to fruits which were analyzed only.

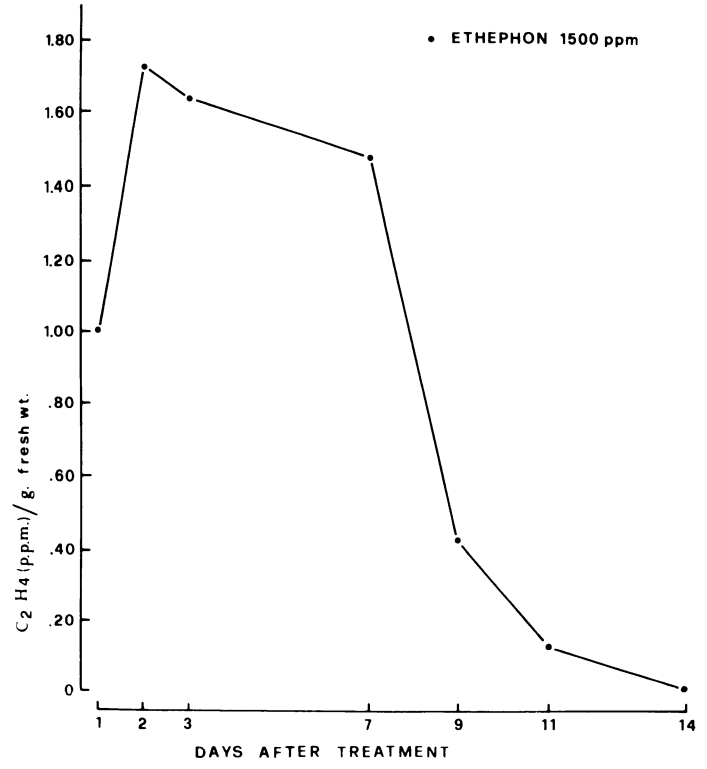

Fig. 3. Ethylene evolution from mature fruits of olive during the 14 day period following application of ethephon. Both leaves and fruits of branch units were sprayed.

20–25% more open stomata than untreated leaves during the 2 week period in which the experiment was in progress.

Discussion

Considerable research effort has gone into the search for acceptable chemicals which will facilitate mechanical harvesting of olives. Some materials at concentrations capable of inducing adequate fruit abscission lead to undesirable side affects such as excessive defoliation. As observed by Lavee (14) and Vitagliano (17) on other cultivars

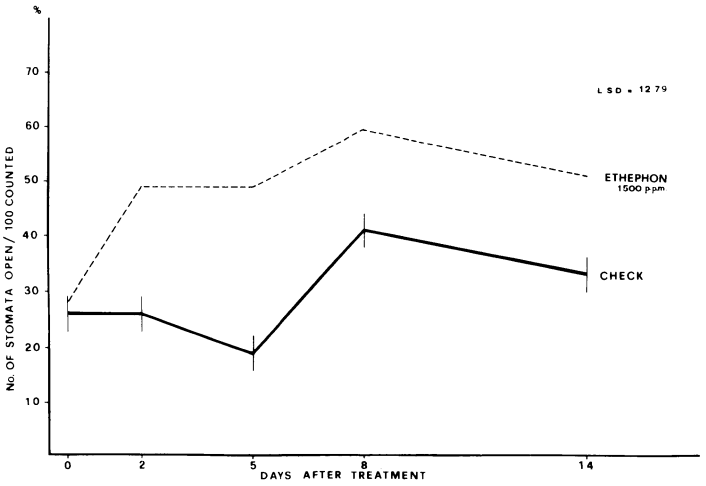

Fig. 4. Effect of ethephon on stomata aperture of olive leaves.

ethephon applied 2 weeks before harvest caused no abnormal defoliation or pathological symptoms, yet gave a marked reduction in FRF.

Gas chromatography studies indicate that ethylene evolution in olive begins as soon as ethephon reaches the fruit tissues, and continues at a high rate for several days. The experiments also indicate that ethephon and/or ethylene can be translocated from leaves into adjacent fruits.

There is also an effect of ethephon treatment on stomatal aperture with a greater number of stomata being open on treated leaves. No attempt was made to quantify the degree of opening of the stomata. It seems likely that this effect of ethephon may have important implications with respect to gas exchange and transpiration. The mechanism for this effect on stomate aperture has not been studied, but since the effect of abscisic acid on stomata is well documented (2, 12, 15, 19), an interaction study between ethephon and abscisic acid is suggested.

The results of this study show that ethephon has definite potential for reducing FRF in cultivars of olive for oil processing, harvested late in December when the fruits are fully mature.

Literature Cited

1. Blanpied, G. D. 1971. Apparatus for ethylene extraction from plant tissue. *Hort Science* 2:132–134.
2. Cummins, W. R., Kende, H., and Raschke, K. 1971. Specifications and review of the rapid stomatal response to ABA. *Planta* 99:347–351.
3. Fiorino, P., and Vitagliano, C. 1968. Ricerca sull'efficacia delle "acque di vegetazione". *L'Italia Agricola*, 10:859–963.
4. ———, Petruccioli, G., and Parlati, M. V. 1974. Risultati di trattamenti con sostanze inducenti l'abscissione sulla efficienza di una macchina per la raccolta e loro influenza sull'andamento della defogliazione e differenziazione a fiore. *Atti dell'incontro frutticolo sulla raccolta meccanica delle olive*, Foligno, 12th Dec.
5. Fregoni, M., and Roversi, A. 1968. Indagine biometrica sugli stomi di alcune cultivar di pesco. Riv. *Ortoflorofrutt. Ital.* 5:541–548.
6. Gellini, R., Falusi, M., and Sabato, S. 1966. Ricerche sullo impiego in varie epoche dell'acido ascorbico e della glicerina per accelerare l'abscissione delle olive. *Atti della Accademia dei Georgofili* 142(suppl.):3–25.
7. Hartmann, H. T., Fadl, M., and Whisler J. 1967. Inducing abscission of olive fruits by spraying with ascorbic acid and iodoacetic acid. *CA. Agr.* 21:5–7.
8. ———, Heslop, A. J., and Whisler J. 1968. Chemical induction of fruit abscission in olives. *CA. Agr.* 22:14–17.
9. ———, and Tombesi, A. 1969. Possibilité de diminution du cout de la recolte des fruits par l'utilisation de produits chimiques et mayens mechaniques. *Inform. Oléicoles Inter.* 45:33–68.
10. ———, ———, and Whisler, J. 1970. Promotion of ethylene evolution and fruit abscission in the olive by 2-chloroethanephosphonic acid and cycloheximide. *J. Amer. Soc. Hort. Sci.* 95:635–640.
11. ———, El-Hamady, M., and Whisler, J. 1972. Abscission induction in the olive by cycloheximide. *J. Amer. Soc. Hort. Sci.* 97:781–785.

12. Kriedemann, P. E., Loveys, B. R., Fuller, G. L., and Leopold, A. C. 1972. Abscisic acid and stomatal regulation. *Plant Physiol.* 49:842–847.
13. Lavee, S. 1965. Diminuizione della resistenza al distacco delle olive per facilitarne la raccolta meccanica ed a mano. *Atti I Simp. Inter. Racc. Mecc. Olive*, Pescara 1:1–10.
14. ———, Barshi, G., and Haskal, A. 1973. Natural fruit drop and induced abscission to facilitate mechanical harvesting of Manzanillo and Souri olives. *Sci. Hort.* 1:63–75.
15. Mittelfeusen, C. J., and Van Steveninck, R. F. M. 1970. Rapid action of abscisic acid on photosynthesis and stomatal resistence. *Planta*, 97:83–86.
16. Vitagliano, C. 1969. Ricerche sull'impiego di prodotti chimici atti a facilitare la raccolta delle olive. Ricerche comparative sull'efficacia di trattamenti con "olii di oliva" e con "acqua di vegetazione". *Sci. e Tec. Agr.*, 2:160–168.
17. ———, 1974. L'impiego di sostanze cascolanti nella raccolta meccanica delle olive: azione dei composti 'etilenpromotori'. *Atti dell'incontro frutticolo sulla raccolta mecanica delle olive*, Foligno, 56–60, 12th Dec.
18. ———, and Zucconi, F. 1968. Effetto di prodotti diversi sulla variazione della resistenza al distacco delle drupe. *Sci. e Tec. Agr.*, 6:185–193.
19. Wright, S. T. C., and Hiron, R. W. P. 1969. (+)-Abscisic acid, the growth inhibitor induced to detached wheat leaves by a period of wilting. *Nature* 224:719–720.

Effects of Light, Temperature, and 2′,4′-Dichloro-1-Cyanoethanesulphonanilide on Degreening of Regreened 'Valencia' Oranges[1]

C. W. Coggins, Jr. and A. E. Hall[2]
University of California, Riverside

Abstract. Degreening occurred when 1000 ppm 2′,4′-dichloro-1-cyanoethanesulphonanilide (R33417) was applied preharvest or postharvest to regreened 'Valencia' oranges [*Citrus sinensis* (L.) Osbeck] when light was present. Part of the light effect may have been due to increased rind temperatures because some degreening occurred when treated fruit were held in darkness at 40°C. Little or no degreening, however, occurred in darkness at 25 or 4°C. Some postharvest degreening occurred in the absence of R33417 in darkness at 40°C and considerable degreening occurred on fruit which were exposed to light but not treated with R33417 even when rind temperatures were considerably lower than 40°C. Results obtained with untreated fruit agree with the currently accepted view that intense light can cause chlorophyll destruction, however, excised orange fruit were much more susceptible to degreening by intense light than attached citrus leaves. Based on the combined effects of light, temperature, and R33417 on degreening we speculate that the chemical potentiates the destructive effects of intense light and high temperatures on chlorophyll. Evidence that light does not convert R33417 into a biologically active compound, and preliminary evidence that R33417 reduces the extent of ethylene degreening are presented.

During the maturation of 'Valencia' oranges, the chlorophyll content of the rind decreases and carotenoids accumulate. In production areas where maturation coincides with warm days and cool nights, virtually all of the chlorophyll disappears. If mature fruit are kept on the tree during the summer months, which is a common practice in many parts of the world, chlorophyll returns to the rind and carotenoid content decreases. This is referred to as regreening. The magnitude of regreening depends, among other things, on environmental conditions and cultural practices, but these aspects of the problem are beyond the scope of this paper.

Degreening of regreened fruit can be accomplished by prolonged exposure of harvested fruit to ethylene in a warm, humid atmosphere. However, this procedure hastens rind senescence (1) and thus increases storage and shelf-life problems. In view of the importance of regreening to the fresh fruit market, we are interested in alternative methods to combat the problem. During a search for compounds which will modify the pigmentation of citrus fruits, we confirmed that R33417 (Fig. 1) can cause degreening, as originally suggested by ICI Plant Protection Limited. Our purpose was to document the biological activity of R33417 and to describe the influence of light and temperature on degreening and on the effectiveness of the compound.

[1] Received for publication November 2, 1974.
[2] Department of Plant Sciences. The authors gratefully acknowledge the California Citrus Advisory Board for financial support, E. F. George, ICI Plant Production Limited, for supplying R33417, G. L. Henning, C. W. Asbell, and J. C. F. Knapp for technical assistance, and E. F. Wallihan, Dept. of Soil Science and Agricultural Engineering for the use of his reflectance meter.

Materials and Methods

Preharvest and postharvest treatments were applied to selected regreened fruit by immersion for 3 min in 95% ethanol or in 95% ethanol containing 1000 ppm R33417. Chlorophyll content of the rind was measured at 9 specific spots on each fruit at the beginning of the experiment and at specified times thereafter with a reflectance meter developed by Wallihan (4) which reads directly in absorbance units. Based on our calibration data, a decrease in absorbance of 0.10 represents a loss of 4.6 μg chlorophyll cm^{-2}. The relation between absorbance over the range of 0.20 to 0.40 and chlorophyll from 0.6 to 9.8 μg cm^{-2} was linear. To put this into perspective, a fruit with an absorbance of 0.20 appears to be essentially free of chlorophyll while a fruit with an absorbance of 0.40 is definitely green. A randomized complete block design was used with blocking based on initial chlorophyll content of the rind. The average absorbance change (ΔA) per fruit was used in statistical evaluations. Light, temperature, and humidity conditions for the postharvest experiments were controlled.

The possibility that light converts R33417 into a biologically active

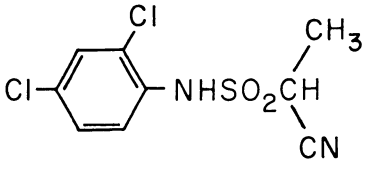

Fig. 1. Structural formula of 2′-4′-Dichloro-1-cyanoethanesulphonanilide (R33417).