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Influence of preharvest ethephon applications on ripening of Japanese plum (Prunus salicina)

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INFLUENCE OF PREHARVEST ETHEPHON APPLICATIONS ON RIPENING OF JAPANESE PLUM (PRUNUS SALICINA)

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This project, by George M. Leavitt Jr. is accepted in its present form by the Department of Botany and Range Science of Brigham Young University as satisfying the project requirement for the degree of Master of Science.

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INTRODUCTION

Ethephon has advanced maturity of apples (1,8,9), peaches (4,16), prunes (15), grapes (11,19), figs (7), and tomatoes (10). This response has been measured in terms of earlier exterior fruit color development, decrease in flesh firmness and an occasional increase in soluble solids. These reactions could potentially be used to advantage by fresh plum growers to manipulate harvest timing and enhance fruit attractiveness.

Trials were established in 1975 at the University of California Kearney Horticultural Field Station, Parlier, California to further evaluate the ripening response of two Japanese plum cultivars, 'Queen Rosa' and 'El Dorado' to ethephon applications. Queen Rosa was particularly selected for its tendency for poor skin color near the stem end of the fruit. In addition to observing and measuring preharvest ripening responses, the tests included evaluation of postharvest ripening patterns.

METHODS AND MATERIALS

The El Dorado trial was designed to investigate both time and rate of application. Timing dates were to approximate four and two weeks before normal harvest. Due to unseasonably cool weather, the maturity date was delayed and treatments were actually applied six and four weeks before harvest.

Rates of 0, 50, and 100 ppm were applied to runoff on each date by dilute hand gun sprayer at 300 psi using four to five gallons per tree. Eighteen single tree plots were selected for uniform growth and crop level. These were utilized in a randomized complete block design of two application timings, three application rates and three replications.

The Queen Rosa trial had one application timing which was actually 33 days before the first harvest. Rates of 0, 50, and 100 ppm were applied, as previously described, to single tree plots in a randomized complete block design with three replications.

Fruit sampling began in the El Dorado trial on the first application date by measuring cheek diameter of 30 fruit. Beginning June 27 and continuing on June 30, July 3, July 7 and July 10 samples (10 fruit per tree) were collected for color, flesh pressure and soluble solid measurements. Skin color measurements were made by visual rating. A Hunter Spring [R] force gauge with a 5/16" tip and a one to ten pound pressure range, mounted on a U. C. Pressure Tester was used for measuring flesh pressures.

These readings were taken on pared cheeks of each fruit and then averaged. Each fruit was sampled individually for soluble solids with a temperature compensating refractometer by taking a slice from the stylar end and hand squeezing juice onto the glass surface. Fruit weight measurements were made on July 3 and 10 and tree yields were taken on July 10.

The Queen Rosa fruit sampling and measuring methods were similar to the El Dorado trial with the exception that larger lot samples of approximately 30 pounds each were collected on both harvest dates, June 30 and July 7, from each tree for postharvest studies. Samples from the postharvest lots were tested for flesh firmness, acid and soluble solids upon arrival at U. C. Davis. The lots were promptly cooled, stored at 32 degrees Fahrenheit for one week and then transferred and maintained at 68 degrees Fahrenheit for ripening. After 24 hours, daily readings on flesh firmness and acid levels were made for seven consecutive days on sample lots of ten truit each. Additional fruits from the lots were placed in respiration chambers for carbon dioxide and ethylene evolution measurements. Carbon dioxide levels were measured following the colorimetric procedure of Claypool and Keefer (5). Air samples were removed from the chambers and placed in a gas chromatograph to measure ethylene evolution using the method of E. C. Maxie, et al. (13).

Statistical analyses of the data were made by use of Duncan's Multiple Range Test.

RESULTS

Preharvest and Harvest

Fruit flesh of El Dorado plum was softer, (i.e. less firm) at all sampling dates in both ethephon treatments than the control (Table 1), but there was no difference between 50 and 100 ppm. With Queen Rosa the ethephon treatments were again softer than the control and there was a difference between 50 ppm and 100 ppm (Tables 3,4). This loss of fruit firmness following application of ethephon is consistent with results obtained by Proebsting and Mills (15) on 'Early Italian' prunes and Jensen, et al. (11) on 'Tokay and Emperor' table grapes. El Dorado samples tested on July 14 (Table 1) were firmer than July 7 samples but this can apparently be accounted for by failure of the fruit to reach room temperature before measuring, following cold storage.

Soluble solids were not affected by concentrations of ethephon (Tables 2 and 3). These results differ from Sims et al. (16) work on peach cultivars, Proebsting and Mills (15) on prunes and Couey and Williams (6) on apples where an increase of soluble solids was observed. Queen Rosa soluble solids increased from July 2 to July 9 (Table 4) while acid levels decreased. Acid levels (Table 4) for Queen Rosa harvest samples also decreased with increased rate of ethephon. An occasional decrease in acid with ethephon applications is consistent with observations in other cultivars (6,11,12, 18,19). There were no differences in fruit weights by treatment in either cultivars nor in tree yield of El Dorado plum.

External fruit color observations were made on El Dorado on June 18; fourteen and seven days, respectively, after the first and second applications. Control treatments and 50 ppm treated on June 11 were green with no purple blush. 100 ppm applied June 11 and 50 ppm applied May 28 were just beginning to show a few fruits with some scattered pink coloration at the stylar end. 100 ppm applied May 28 had many pink to dark red fruits at the stylar end and these were scattered throughout each tree. However, by harvest, no major visual color differences were apparent between the two application dates. The 50 ppm rate was slightly lighter than the 100 ppm, in the deep purple color typical of El Dorado, but little difference was apparent at harvest between the two treatment rates. Control fruit met legal maturity color standards but was not as fully colored nor as intensely colored as ethephon treated fruit. In this trial at least three to four weeks elapsed from ethephon application to full color development. An additional subjective color measurement comparing amount of fruit harvested first vs. second pick was planned, but due to the cool season, early ripening fruit was held on the tree and only one pick was made. Desired increased coloration at the stem end of Queen Rosa did not occur.

Slight stylar end splitting of the skin or flesh, observed by Bradley et al. (2) on apricots and also on El Dorado plums in very early season treatments during 1974 was not apparent in 1975 on either Queen Rosa or El Dorado.

Postharvest

Postharvest effects of ethephon on Queen Rosa indicated acid levels remained constant during storage (Table 6). Differences of carbon dioxide levels vary with date in storage and rate of ethephon (Table 6). Fruit treated with 100 ppm ethephon evolved more carbon dioxide than untreated fruit during postharvest ripening for both picking dates. The 50 ppm rate also evolved more carbon dioxide than untreated fruit for the first harvest but not the second. Carbon dioxide evolution decreased with time for the first harvest but not the second. However, levels tended to be somewhat erratic throughout these tests and like Uota (18), were not considered to provide good measurement of fruit ripening rates.

Another measurement of postharvest ripening rate is ethylene evolution. The rate of ethylene evolution for both harvests is shown (Figure 1). Levels of ethylene for the 100 ppm treatment precede similar levels in the untreated checks by about three to five days. The rate of increase in ethylene evolution for the second harvest is similar for the checks but again a lag of three days is present. It should be noted that the 50 ppm and check treatments attain the same level of ethylene evolution $1\frac{1}{2}$ and 3 days later, respectively, than the 100 ppm. This pattern is similar to the flesh pressure data.

Flesh pressure decreased with increased ethephon rates and storage (Figure 2, Table 6). From July 8 to July 14 and July 16 to July 21, treatments were significantly different from each other with 100 ppm being the softest and control (0 ppm) the firmest.

When 50 ppm and 100 ppm are plotted for flesh pressure and compared to the control, a maturity difference of $5\frac{1}{2}$ days and 9 days, respectively, occurs.

To determine if the rate of maturation was greater with ethylene treated fruit during the postharvest period flesh pressure readings from Figure 2 were tested and found to be parallel. Hence, no interaction occurred between ethephon rates and fruit softening in storage. Another comparison was made between the 100 ppm treatment first pick and the control second pick. These treatments were selected due to similarities in acid, flesh pressure and carbon dioxide evolution during postharvest sampling (Table 6). Postharvest performance of these treatments was compared in terms of rate of change in flesh firmness and evolution of carbon dioxide and ethylene. These comparisons indicate no differences exist in postharvest performance and thus the shelf life is assumed to be similar (Table 5).

CONCLUSION

Ethephon could potentially be used to advance fruit maturation in terms of hastening external coloration and decreasing flesh firmness. However, in this test soluble solids levels were not advanced. This response could potentially be utilized to make more efficient use of labor and packing facilities with other advantages being earlier harvests, reduction of number of harvests and manipulation of fruit shipments to insure even flow of fruit to market. Other cultivars should be tested for variation which might be due to cultivars.

Postharvest evaluations of preharvest ethylene treated fruits indicate similar rates of ripening when compared to untreated fruit. At 50-100 ppm, ethephon has a powerful effect on hastening coloration and decreasing flesh firmness of the two plum cultivars tested.

Table 1. Effect of ethephon on flesh firmness of El Dorado plum.

Rate in ppm	Flesh Firmness				
	June 27	June 30	July 3	July 7	July 14
0	11.3a	9.4a	9.0a	7.5a	8.2a
50	7.8b	7.8b	6.4b	5.4b	5.4b
100	6.8b	5.4b	5.3b	4.3b	4.8b

Sig. to 1%

Table 2. Effect of ethephon on soluble solids, weight/fruit and yield of El Dorado plum.

Rate in ppm	Soluble Solids					Weight/Fruit Grams		Yield
	June 27	June 30	July 3	July 7	July 14	July 3	July 10	July 10
0	10.3a	10.6a	10.8a	10.4a	10.9a	60.6a	64.9a	245.5a
50	10.4a	10.9a	11.3a	10.8a	11.4a	61.8a	63.8a	241.8a
100	10.5a	10.9a	11.2a	10.9a	11.5a	63.4a	68.5a	245.3a

Sig. to 1%

Table 3. Effect of ethephon on Queen Rosa maturation.

Rate in ppm	Firmness	Soluble Solids	Weight/Fruit Grams-7/3
0	6.4a	12.1a	117.1a
50	4.9b	11.9a	114.1a
100	4.1c	12.2a	117.4a

Sig. to 1%

Table 4. Comparison of Queen Rosa maturity at harvest.

	Firmness	Soluble Solids	Acid
July 2	6.2a	11.4b	.886a
July 9	4.0b	12.2a	.624b
Rate in ppm			
0	6.4a	11.5a	.936a
50	4.8b	12.0a	.720b
100	4.0c	12.0a	.610c

Sig. to 1%

Table 5. Comparison of first pick (100 ppm) and second pick control (0 ppm) flesh pressures, acid levels and rate of CO_2 evolution.

Treatment	Flesh Pressure	Titratable Acid	CO_2 Rate $MgCO_2$/Kg/Hr
100	3.7a	3.5a	20.8a
0	3.8a	3.8a	22.0a

Sig. to 1%

Table 6. Postharvest effect of ethephon on acidity, firmness and CO_2 rate of Queen Rosa plum.

	First Pick				Second Pick		
Date	Titratable Acidity	Flesh Firmness	CO_2 Rate Mg CO_2/Kg/Hr	Date	Titratable Acidity	Flesh Firmness	CO_2 Rate Mg CO_2/Kg/Hr
July 8	.84a	5.3a	23.4a	July 16	.73a	4.1a	25.7a
July 9	.91a	5.3a	21.6ab	July 17	.70a	3.8a	17.0c
July 10	.88a	4.8ab	23.3a	July 18	.80a	3.2b	24.7ab
July 11	.97a	4.7b	20.8bc	July 19	.79a	2.4c	22.5b
July 12	.94a	4.5b	19.1cd	July 20	.78a	2.0d	22.9b
July 13	1.00a	4.7b	18.0d	July 21	.80a	1.8d	27.4a
July 14	.95a	3.6c	15.1e	July 22	—	—	25.3a
Treatment 7/8–7/15				Treatment 7/16–7/22			
0	.93a	6.0a	18.0b	0	.90a	3.8a	22.0b
50	.94a	4.5b	19.8a	50	.79ab	2.7b	22.9b
100	.91a	3.5c	20.8a	100	.61b	2.2c	26.0a

Sig. to 1%

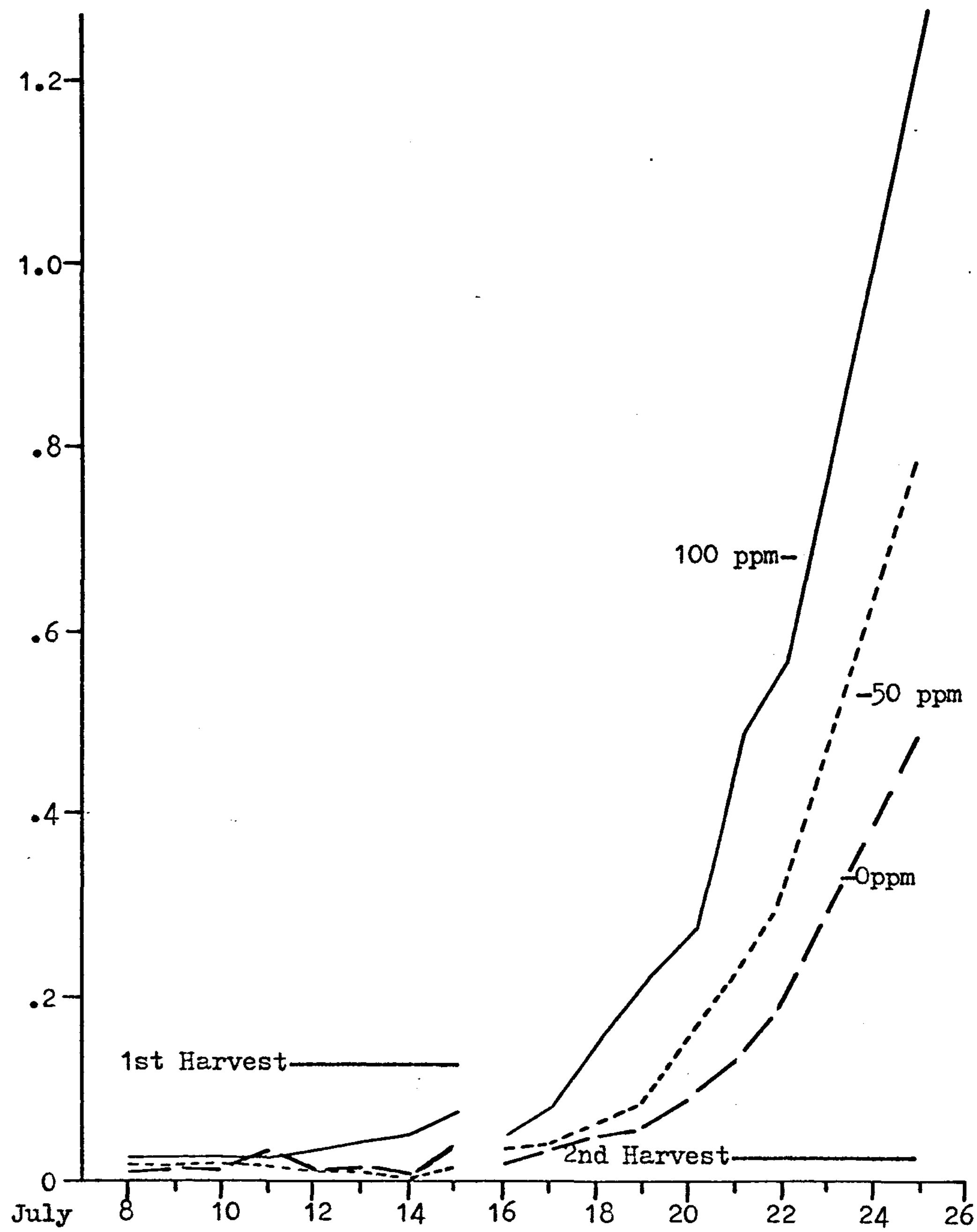

Fig. 1. Queen Rosa ethylene evolution July 8–July 25.

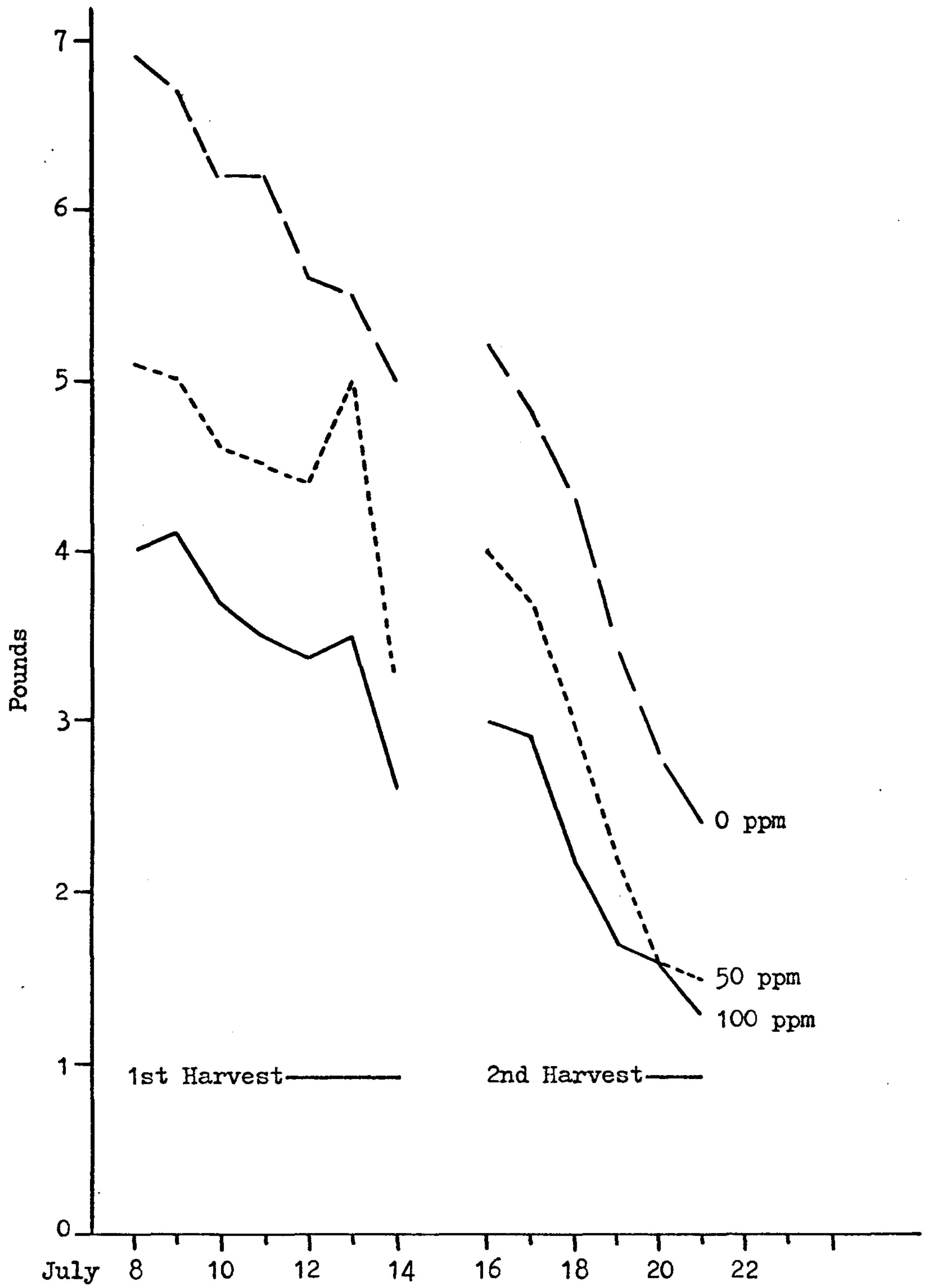

Fig. 2. Queen Rosa flesh pressures 0, 50, 100 ppm July 8–July 21.

LITERATURE REVIEW

Blanpied, G. D., C. G. Forshey, W. C. Styles, D. W. Green, W. J. Lord, and W. J. Bramlage, 1975. Use of ethephon to stimulate red color without hastening ripening of 'McIntosh' apples. J. Amer. Soc. Hort. Sci. 100(4):379-381.

Bradley, Muriel V., Nasr Marei and Julian C. Crane, 1969. Morphological and histological effects of ethrel on the apricot, Prunus armeniaca L., as compared with those of 2,4,5-trichlorophenoxyacetic acid. J. Amer. Soc. Hort. Sci. 94: 316-318.

Burg, S. P., 1962. The physiology of ethylene formation. Ann. Rev. Plant Physiol. 13:265-302.

Byers, Ross E., and Frank H. Emerson, 1973. Effect of SADH and ethephon on peach fruit growth and maturation. HortScience Vol. 8(1) 48-49.

Claypool, L. L., and R. M. Keefer, 1942. A colorimetric method for CO_2 determination in respiration studies. Proc. Amer. Soc. Hort. Sci. 40:177-186.

Couey, H. Melvin, and Max W. Williams, 1973. Preharvest application of ethephon on scald and quality of stored 'Delicious' apples. HortScience. Vol. 8(1) 56-57.

Gerdts, Marvin and Gary Obenauf, 1972. Effects of preharvest applications of ethephon on maturation and quality of calmyrna figs. California Agriculture. Vol. 26, No. 5:8-9.

Greene, D. W., W. J. Lord, W. J. Bramlage, and F. W. Southwick, 1974. Effects of low ethephon concentrations on quality of 'McIntosh' apples. J. Amer. Soc. Hort. Sci. 99(3):239-242.

Greene, D. W. and W. J. Lord, 1975. Influence of light and spray coverage on red color development of ethephon-treated 'McIntosh' apples. HortScience, Vol. 10(3):254-255.

Iwahori, Shuichi and James M. Lyons, 1969. Accelerating tomato fruit maturity with ethrel. California Agriculture, Vol. 23, No. 6:17-18.

Jensen, Fred L., George M. Leavitt, and William L. Peacock, 1975. Effects of gibberellin and ethephon on grapes. Blue Anchor, Vol. 52, No. 2:25-27.

Looney, Norman E., 1975. Control of ripening in 'McIntosh' apples. Some growth regulator effects on preharvest drop and fruit quality at four harvest dates. J. Amer. Soc. Hort. Sci. 100(4):330-332.

Maxie, E. C., I. L. Eaks, N. F. Sommer, Henry L. Rae, and Salah El Batal, 1965. Effect of gamma radiation on rate of ethylene and carbon dioxide evolution by lemon fruits. Plant physiol. 40:407-409.

Pollard, James E., 1974. Effects of SADH, ethephon and 2,4,5,-T on color and storage quality of 'McIntosh' apples. J. Amer. Soc. Hort. Sci. 99(4):341-343.

Proebsting, E. L., and Harlan H. Mills, 1969. Effects of 2-Choro-ethane phosphonic acid and its interaction with gibberellic acid on quality of 'Early Italian' prunes. J. Amer. Soc. Hort. Sci. 94:443-446.

Sims, E. T., Jr., C. E. Gambrell, Jr., and G. E. Stembridge, 1974. The influence of (2-Chloroethyl) phosphonic acid on peach quality and maturation. J. Amer. Soc. Hort. Sci. 99(2): 152-155.

Unrath, C. R., 1972. Effects of preharvest applications of ethephon on maturity on quality of several apple cultivars. Hort-Science, Vol. 7(1):77-79.

Uota, M., 1954. Effect of temperature and ethylene on evolution of carbon dioxide, ethylene, and other oxidizable volatiles from three varieties of plum. Amer. Soc. Hort. Sci. 65: 231-243.

Weaver, Robert J., and Ralph Montgomery, 1974. Effect of ethephon on coloration and maturation of wine grapes. Amer. J. Enol. Viticult., Vol. 25, No. 1:39-41.

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ABSTRACT

Ethephon, applied to two plum cultivars, 'Queen Rosa' and 'El Dorado', at 50 and 100 ppm, gave varying responses on the ripening process. Soluble solids remained unchanged while acid levels dropped. Increased ethylene evolution, color advancement and decreased flesh pr observed.