NURSERY STOCK DEFOLIATION USING VARIOUS COMBINATIONS OF ETHEPHON, ENDOTHALL AND CYCLOHEXIMIDE

by

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MANUSCRIPT

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Nursery Stock Defoliation Using Various Combinations Of Ethephon, Endothall and Cycloheximide.[1]

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Abstract: Single applications of 250 - 500 ppm ethephon (21.6% (2-chloroethyl phosphonic acid), 250 - 500 ppm endothall (15.9% mono (N, N - dimethylalkylamine) salt of 7 - oxobicyclo (2.2.1) heptane - 2, 3 - dicarboxylic acid equivalent 5.5%) along with 5 or 10 ppm of cycloheximide (4.22% (3- (2- (3,5-dimethyl -2 oxocyclohexyl) -2 -hydroxyethyl) -glutarimide) provided the best defoliation with the least amount of damage on two-year old Malus, 'Red Delicious', 'Winesap', and 'Hopa' and one-year old seedlings of apple and Pyrus calleryana Decne. Treatments containing endothall resulted in significantly greater defoliation.

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[3]Plant materials were donated by Skinner Nursery, Topeka, Kansas. Cycloheximide (Acti-Aid) was supplied by the Upjohn Company, endothall (Des-1-Cate) by Pennwalt Corporation and ethephon (Ethrel) by Amchem Products, Inc.

Chemical defoliation of nursery stock would prevent either delayed digging or costly mechanical removal of leaves. Larsen (4) has outlined the characteristics of a good chemical defoliant, but many chemicals and chemical combinations tried so far have not uniformly satisfied these characteristics (1, 3 - 9, 11, 13). Most chemical defoliants have not been accepted commercially on a wide basis (14). The most widely used defoliants are ethephon and Dupont WK (D-WK) surfactant (90% dodecyl ether of polythelene glycol) applied seperately or in combination (5, 7, 8, 14). 200 - 400 ppm ethephon and 1 - 2% D-WK surfactant with 1 - 3 applications reacted synergistically to provide good defoliation on many species (8), allowing the use of less chemical and reducing the cost of defoliation. Combinations of endothall and ethephon at 1200 - 2400 ppm promoted quick defoliation (2, 11 - 13) of woody plants. Cycloheximide, a harvest aid in citrus (9), provided good defoliation of nursery stock but at 25 - 50 ppm induced shoot damage. This study was developed to find the combination of chemicals which would provide the best defoliation of nursery stock at low chemical concentrations and with single applications.

There were two tests. Test 1; 2-year old grafted plants of 'Red Delicious' and 'Winesap' apple, and 'Hopa' crabapple were sprayed with different combinations and concentrations of ethephon, endothall and cycloheximide (Table 1). 1% polyoxyethlene (20) sorbitan monolaurate (Tween - 20) was added as a surfactant and in addition 1% component B of Acti-Aid, a specific surface-active agent for cycloheximide (tridecyl alcohol derivative) was added whenever cycloheximide was included in a

treatment. Sprays were applied to run-off at a commercial nursery on September 29, 1975. Average day temperature was 19°C and average relative humidity was 56%. Bright sun prevailed during the application, although a one inch rain fell 7 hours after spraying. Initial leaf counts were taken before spraying and final leaf counts were taken 12 days later. Defoliation was expressed as a percent of the initial leaf count. Many defoliants caused shoot damage. The length of the damaged portion of the shoot was also measured twelve days after spraying and expressed as a percent of total shoot length. Plants remained in the field after the treatment. General plant condition was again evaluated visually on May 3, 1976, using a scale of 0% for no damage and 100% for complete kill.

Test 2: one-year old seedlings of apple and pear were sprayed on October 1, 1975 under climatic conditions similar to Test 1 except there was no rain for several days after the plants were sprayed. Defoliation and shoot damage was visually evaluated. Plants sprayed with the most promising treatments were dug and stored at 3°C and 95% relative humidity. These plants were replanted into containers in May, 1976. Percent mortality was recorded as damage.

One-way analysis of variance was performed on arcsin transformed data; mean separation was calculated at the 5% level using least significant difference (LSD).

Generally, addition of endothall improved defoliation (Table 1 and Figure 1). Similar results were obtained by Davis et al. (2) and Street et al. (13). Apparently, endothall enchanced the efficiency of ethephon by inhibiting its transport out of the leaf (12). Cycloheximide seemed to have a synergistic action in combination with ethephon and endothall (Table 1) improving percent defoliation in most cases.

There was also a species and chemical interaction. 'Red Delicious' and 'Winesap' were easier to defoliate than pear and apple seedlings. Larsen (4) also observed that pear was very difficult to defoliate.

There was very little shoot damage observed after defoliation in the fall. 'Red Delicious' had 25 - 50% damage when treated with higher concentrations of chemicals (1000 - 1500 ppm ethephon, 500 - 1000 ppm endothall). Treatments which gave 85 - 100% defoliation at lower concentrations of defoliants resulted in plant damage of less than 10%.

Damage recorded in May revealed that 'Red Delicious', 'Winesap' and pear seedlings suffered heavier damage than that recorded in October of 1975 (Table 2). (For purpose of brevity only partial data has been presented). Most of the treatments resulted in more than 50% damage. Damage to 'Hopa' crabapple and apple seedling was not severe. Pear has been reported to be particularly sensitive to chemical defoliants (4, 5, 9). The extensive damage on other cultivars may not have been caused entirely by the chemical defoliants. After defoliation, the day temperatures were 20 - 25^{o}C for ten days. Many defoliated plants broke bud and initiated shoot growth. Approximately 65% of 'Red Delicious', 60% of 'Winesap' and 35% of 'Hopa' crabapple broke bud. Percent damage was in proportion to the percent plants that broke bud. Apple seedlings which were cold stored did not show much damage.

TABLE 1: Percent defoliation promoted by combinations of ethephon, endothall and cycloheximide on nursery stock in October, 1975.[z]

CONCENTRATIONS (ppm)			TEST 1			TEST 2	
Ethephon	Endothall	Cycloheximide	Red Delicious	Wine sap	Hopa Crabapple	Apple Seedlings	Pear Seedlings
250	--	5	21.00 hi	29.75 k	18.75 jk	00.00 h	00.00 j
250	--	10	46.66 fgh	36.25 k	31.75 ij	00.00 h	00.00 j
250	250	5	89.50 abcde	91.25 bcdefg	70.25 defg	23.33 fg	6.67 hij
250	250	10	98.50 a	98.50 abc	93.25 abc	83.33 a	16.67 efgh
250	500	5	90.80 abcd	97.50 abc	97.50 ab	81.66 a	70.00 abc
250	500	10	98.25 a	100.00 a	93.25 abcde	80.00 ab	68.33 abc
500	--	5	63.25 defg	26.25 k	27.75 ijk	0.00 h	1.67 ij
500	--	10	30.00 hi	24.50 k	28.75 ijk	0.00 h	0.00 j
500	250	5	92.85 a	99.00 ab	67.50 fgh	33.33 efg	6.67 hij
500	250	10	94.75 ab	94.75 abcde	82.50 abcdef	30.00 efg	33.33 def
500	500	-	67.25 defg	67.50 j	55.25 ghi	25.00 fg	10.00 ghij
500	500	5	93.25 abc	97.75 abc	95.00 abcd	73.33 abc	58.33 bcd
500	500	10	89.70 abcd	94.00 abcdefg	99.00 a	65.00 abcd	56.67 bcd
500	1000	-	81.00 bcde	91.50 cdefghi	66.25 fgh	81.66 a	83.33 a
1000	--	5	72.25 cdef	24.00 k	19.50 jk	16.66 gh	0.00 j
1000	--	10	45.70 fgh	23.00 k	31.00 ij	0.00 h	6.67 hij
1000	250	5	89.00 abcd	97.00 abcd	68.70 fgh	28.33 efg	23.33 efg
1000	250	10	99.25 a	96.25 abcde	68.50 fgh	41.66 cdef	16.67 fghi
1000	500	-	82.3 bcde	79.00 hij	47.50 hij	31.00 efg	36.67 de
1000	500	5	58.8 defg	96.75 abc	88.25 abcdef	71.66 abc	58.33 bcd
1000	500	10	80.5 bcde	94.00 abcd	96.75 abcd	71.66 abc	36.67 de
1000	1000	-	86.50 abcde	90.50 cdefgh	96.00 abcd	70.00 abc	78.33 ab
1500	--	5	54.00 efgh	31.25 k	17.50 jk	0.00 h	3.33 ij
1500	--	10	57.5 efgh	21.50 k	18.00 jk	0.00 h	10.00 hij
1500	250	5	91.00 abcd	75.75 ij	71.75 efg	20.00 efgh	12.50 efghi
1500	250	10	86.25 abcde	89.75 defghi	71.75 efgh	50.00 bcdef	35.00 def
1500	500	-	88.25 abcde	83.00 fghij	80.00 cdefg	0.00 h	0.00 j
1500	500	5	71.00 cdef	92.75 abcdef	78.25 bcdefg	70.00 abc	56.67 bcd
1500	500	10	78.25 bcde	83.75 ghij	87.25 abcdef	55.00 abcde	51.67 cd
1500	1000	-	88.25 abcde	87.50 efghi	96.00 abc	36.66 def	33.33 def
Control	--	-	0.00 i	1.500 l	5.25 k	0.00 h	0.00 j

[z]Mean separation within columns at 5% level using L. S. D.

TABLE 2: Percent shoot damage[z] of deciduous nursery stock sprayed with ethephon, endothall, and cycloheximide[y], evaluated during May, 1976.[x]

CONCENTRATIONS (ppm)			TEST 1			TEST 2	
Ethephon	Endothall	Cycloheximide	Red Delicious	Wine sap	Hopa Crabapple	Apple Seedlings	Pear Seedlings
250	250	5	0.75 g	48.75 defgh	4.25 bcd		
250	500	5	34.66 cdefg	81.00 abcde	11.25 abcd	9.9	54.82
500	250	5	70.00 abcd	46.25 efghi	3.33 cd		
500	500	-	7.00 fg	3.75 jkl	0.00 d		
500	500	5	78.75 abc	67.50 abcdefg	5.00 bcd	15.60	75.75
500	1000	-	76.25 abc	46.25 efghijk	15.00 abcd	14.80	91.50
1000	250	5	72.50 abcd	25.00 fghijkl	1.67 cd		
1000	500	-	6.67 efg	26.25 ghijkl	2.50 cd		
1000	500	5	76.67 abcd	72.50 abcdef	30.00 ab	17.80	47.90
1000	1000	-	100.00 a	73.75 abcde	8.33 bcd	11.10	
1500	250	5	85.00 abcd	8.75 hijkl	1.25 d		
1500	500	-	48.33 abcdef	21.25 ghijkl	7.50 bcd		
1500	500	5	45.00 cdefg	98.75 a	16.67 abcd		
1500	1000	-	72.50 abcd	95.00 abc	40.00 a		
Control			0.00 g	0.00 l	0.00 d		

[x] Mean separation within columns at 5% level by L. S. D.

[y] Plants were sprayed during October, 1975.

[z] No damage was rated 0% and complete kill was rated 100%

FIGURE 1: Defoliation of 'Winesap' apple induced by different combinations of ethephon, endothall and cycloheximide during October, 1975. [z]

[z]Numbers below each plant indicate the concentrations in ppm of ethephon, endothall, and cycloheximide, applied.

FIGURE 1

LITERATURE CITED

(1). Cummins, J. N. and P. Fiorino. 1969. Pre-harvest defoliation of apple nursery stock using Ethrel. HortScience 4:339-341.

(2). Davis, J. T., J. P. Sterrett and G. R. Leather. 1972. Ethephon-endothall as a chemical abscissor of bean leaves. HortScience 7:478-480.

(3) Kozel, P. C. 1968. Ethrel: A new chemical defoliant. Buckeye Nurseryman 10(708):6

(4). Larsen, F. E. 1967. Five years results with pre-storage chemical defoliation of deciduous nursery stock. Proc. Intern. Plant Prop. Soc. 17:157-172.

(5). Larsen, F. E. 1970. Promotion of leaf abscission of deciduous nursery stock with 2-chloroethylphosphonic acid. J. Amer. Soc. Hort. Sci. 95: 662-663.

(6). Larsen, F. E. 1971. Prestorage promotion of leaf abscission of deciduous tree fruit nursery stock with bromodine-ethephon mixtures. HortScience. 6:135-137.

(7). Larsen, F. E. 1972. Surfactant stimulates leaf abscission of tree fruit nursery stock. HortScience 7:563-564.

(8). Larsen, F. E. 1973. Stimulation of leaf abscission of tree fruit nursery with ethephon-surfactant mixtures. J. Amer Soc. Hort. Sci. 98:34-36.

(9). Larsen, F. E. 1975. The effect of cycloheximide and a tridecyl alcohol derivative on leaf abscission of nursery stock. HortScience. 10:61-62.

(10). Rasmussen, G. K. 1975. SADH - cycloheximide effects on orange fruit abscission. HortScience 10:516-517.

(11). Sterrett, J. P., G. R. Leather and W. E. Tozer. 1973. Defoliation response of woody seedlings to endothall/ethephon. HortScience. 8:387-388.

(12). Sterrett, J. P., G. R. Leather and W. E. Tozer. 1974. An explanation for the synergistic interaction of endothall and ethephon on foliar abscission. J. Amer. Soc. Hort. Sci. 99:395-397.

(13). Sterrett, J. P., G. R. Leather, W. E. Tozer, W. D. Foster and D. T. Webb. 1974. Foliar abscission of woody plants with combinations of endothall and ethephon. Weed Science. 22:608-614.

(14). Still, Steven M. 1976. Defoliation of nursery stock for early harvest. Proc. Intern. Plant Prop. Soc. (In print).

A P P E N D I X

APPENDIX 1: Percent shoot damage on deciduous nursery stock sprayed with ethephon, endothall, & cycloheximide in October, 1975.[xy]

CONCENTRATIONS (ppm)			TEST 1			TEST 2	
Ethephon	Endothall	Cycloheximide	Red Delicious	Winesap	Hopa Crabapple	Apple Seedlings	Pear Seedlings
250	---	5	0.00 fg	0.0 h	0.00 e	0.00 c	0.00 f
250	---	10	0.00 g	0.0 h	0.00 e	0.00 c	0.00 f
250	250	5	2.75 efg	11.0 a	0.00 e	5.00 a	0.00 f
250	250	10	6.00 efg	4.50 cdefg	4.00 abcd	5.00 a	1.67 ef
250	500	5	3.800 efg	7.20 abc	1.25 de	5.00 a	3.33 cde
250	500	10	3.25 efg	5.50 abcdef	1.75 e	5.00 a	8.33 abc
500	---	5	1.75 efg	0.0 h	0.00 e	0.00 c	0.00 f
500	---	10	0.00 g	0.75 h	0.00 e	0.00 c	0.00 f
500	250	5	5.00 efg	4.25 abcdef	0.00 e	3.33 ab	0.00 f
500	250	10	10.50 cdefg	1.25 gh	0.25 e	2.50 abc	0.00 f
500	500	-	2.00 efg	0.00 h	0.00 e	1.67 bc	0.00 f
500	500	5	5.75 defg	5.75 abcde	3.50 cde	5.00 a	3.33 cde
500	500	10	7.00 efg	8.75 abc	2.75 bcd	3.33 ab	1.67 ef
500	1000	-	8.25 defg	3.25 cdefg	6.50 ab	5.00 a	10.00 ab
1000	---	5	1.00 fg	0.00 h	0.00 e	1.67 bc	0.00 f
1000	---	10	2.33 efg	0.00 h	0.00 e	0.00 c	0.00 f
1000	250	5	10.75 cdef	5.25 bcdef	0.00 e	5.00 a	0.00 f
1000	250	10	4.500 efg	0.75 h	0.00 e	5.00 a	0.00 f
1000	500	-	3.00 efg	2.50 fgh	0.00 e	5.00 a	3.33 def
1000	500	5	56.25 a	4.25 cdefg	1.0 e	5.00 a	8.33 abc
1000	500	10	27.00 bc	5.00 bcdef	1.0 e	5.00 a	6.67 bcde
1000	1000	-	26.50 bcd	10.50 ab	4.75 abc	5.00 a	15.67 a
1500	---	5	3.00 efg	0.00 h	0.00 e	0.00 c	0.00 f
1500	---	10	5.75 efg	0.00 h	0.00 e	0.00 c	0.00 f
1500	250	5	0.75 fg	0.00 h	1.00 e	5.00 ab	0.00 f
1500	250	10	2.75 efg	3.25 defgh	0.00 e	0.00 c	0.00 f
1500	500	-	3.75 efg	2.75 efgh	0.00 e	0.00 c	0.00 f
1500	500	5	48.75 ab	10.75 ab	0.00 e	5.00 ab	0.00 f
1500	500	10	15.00 cde	4.25 cdefg	0.00 e	5.00 ab	3.33 cde
1500	1000	-	46.25 ab	6.75 abcd	9.25 a	5.00 ab	5.00 bcd
Control			0.00 g	0.00 h	0.00 e	0.00 c	0.00 f

[x]Mean separation within columns at 5% level by L.S.D.

[y]Damage was evaluated during October, 1975.

APPENDIX 2: Percent plant damage[x] of deciduous nursery stock sprayed with ethephon, endothall, and cycloheximide[y] and evaluated during May, 1976.[z]

CONCENTRATIONS (ppm)			TEST 1			TEST 2	
Ethephon	Endothall	Cycloheximide	Red Delicious	Winesap	Hopa Crabapple	Apple Seedlings	Pear Seedlings
250	---	5	0.00 g	0.00 l	0.00 d		
250	---	10	0.00 g	1.25 kl	0.00 d		
250	250	5	0.75 g	48.75 defgh	4.25 bcd		
250	250	10	36.00 bcdefg	50.00 cdefgh	7.50 bcd	7.6	
250	500	5	34.66 cdefg	81.00 abcde	11.25 abcd	9.9	54.82
250	500	10	63.33 abcde	92.50 abcd	21.25 abc		40.3
500	---	5	51.25 abcdef	3.75 jkl	0.00 d		
500	---	10	0.00 g	0.00 l	1.60 d		
500	250	5	70.00 abcd	46.25 efghi	3.33 cd		
500	250	10	31.67 defg	46.25 efgh	7.50 bcd		
500	500	-	7.00 fg	3.75 jkl	0.00 d		
500	500	5	78.75 abc	67.50 abcdefg	5.00 bcd	15.60	75.75
500	500	10	88.33 abc	53.75 bcdefgh	3.33 bcd	10.00	34.50
500	1000	-	76.25 abc	46.25 efghijk	15.00 abcd	14.80	91.50
1000	---	5	2.75 g	3.75 ijkl	0.00 d		
1000	---	10	0.00 g	38.33 efghij	5.00 bcd		
1000	250	5	72.50 abcd	25.00 fghijkl	1.67 cd		
1000	250	10	65.00 abcd	25.00 fghijkl	5.00 bcd		
1000	500	-	6.67 efg	26.25 ghijkl	2.50 cd		
1000	500	5	76.67 abcd	72.50 abcdef	30.00 ab	17.80	47.90
1000	500	10	92.50 ab	43.75 efghi	5.00 bcd	29.50	
1000	1000	-	100.00 a	73.75 abcde	8.33 bcd	11.10	
1500	---	5	13.33 efg	1.67 jkl	0.00 d		
1500	---	10	0.00 g	1.25 kl	0.00 d		
1500	250	5	85.00 abcd	8.75 hijkl	1.25 d		
1500	250	10	57.00 abcde	98.75 a	33.33 ab		
1500	500	-	48.33 abcdef	21.25 ghijkl	7.50 bcd		
1500	500	5	45.00 cdefg	98.75 a	16.67 abcd		
1500	500	10	96.25 a	96.00 ab	1.25 d		
1500	1000	-	72.50 abcd	95.00 abc	40.00 a		
Control			0.00 g	0.00 l	0.00 d		

[x]No damage was rated 0% and complete kill was rated 100%.

[y]Plants were sprayed during October, 1975

[z]Mean separation within columns at 5% level by L.S.D.

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Ethephon (21.6% (2-Chloroethyl) phosphonicacid) at 250, 500, 1000 and 1500 ppm. endothall (15.9% Mono (N, N-dimethylalkylamine) salt of 7-oxobicyclo (2.2.1) heptane - 2,3-dicarboxylicacid equivalent 5.5%) at 0, 250, 500 and 1000 ppm and cycloheximide (4.22% (3 (2- (3,5 - dimethyl-2-oxocyclohexyl) -2hydroxyethyl glutarimide) at 0, 5 and 10 ppm were applied to two year Malus spp. "Red Delicious", Winesap", and "Hopa" and to one year seedlings of Pyrus calleryana Decne. and apple. Concentrations of 250 - 500 ppm of ethephon, 250 - 500 ppm of endothall along with 5 or 10 ppm of cycloheximide provided best defoliation with least amount of damage with a single application. Treatments containing endothall resulted in significantly greater defoliation.