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

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Major Professor

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MANUSCRIPT

This manuscript is written in the style of and for publication in HortScience.

Nursery Stock Defoliation Using Various Combinations Of ${f Ethephon}$, ${f Endothall}$ and ${f Cycloheximide.}^1$

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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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³Plant 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°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. T

Ethephon 250 250 250				1541			
250 250 250	Endothall	Cycloheximide	Red Delicious	Wine sap	Hopa Crahapple	Apple Seedlings	Pear Scediings
250 250	1	5	21.00 hI	29.75 k	18.75 1k	00.00 h	00.00
250	1	10	46.66 fgh	36.25 k	31.75 11	00.00 h	00.00
	250	S	89.50 abcde	91.25 bedefg	70.25 defg	23.33 fg	6.67 h13
250	250	10	98.50 a	98.50 abc	93.25 abc	83.33 a	16.67 efgh
250	200	2	90.80 abcd	97.50 abc	97.50 ab	81.66 a	70.00 abc
250	200	10	98.25 a	100.00	93.25 abcde	80.00 ab	68.33 abc
200	ł	2	63.25 defg	26.25 k	27.75 1jk	0.00 h	1.67 13
500	l	10	30.00 hI	24.50 k	28.75 1jk	0.00 h	0.00
200	250	S	92,85 a	99,00 ab	67.50 fgh	33.33 efg	6.67 h13
200	250	10	94.75 ab	94.75 abcde	82,50 abcdef	30,00 efg	33.33 def
200	200	₽.	67,25 defg	67.50 J	55.25 ght	25.00 fg	10.00 8411
200	200	\$	93.25 abc	97.75 abc	95.00 abcd	73.33 abc	58.33 bed
200	200	10	89.70 abcd	94.00 abedefg	в 00.66	65.00 abcd	56.67 bed
200	1000	1	81.00 bcde	91.50 cdefghi	66.25 fgh	81.66 a	83.33 a
1000	;	s	72.25 cdef	24.00 k	19.50 Jk	16.66 gh	0.00
1000	1	10	45.70 fgh	23.00 k	31.00 11	0.00 11	6.67 1113
1000	250	2	89.00 abed	97,00 abcd	68.70 igh	28.33 efg	23.33 efg
1000	250	10	99.25 a	96.25 abcde	68.50 fgh	41.66 cdef	16.67 fgh1
0001	200	31	82.3 bcde	79.00 htj	47.50 htj	31.00 efg	36.67 de
1000	200	2	58.8 defg	96.75 abc	88.25 abcdef	71.66 abc	58.33 bcd
1000	200	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	;	S	54.00 efgh	31.25 k	17.50 Jk	0.00 h	3, 13 11
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 13	71.75 efg	20.00 efgh	12.50 efgh1
1500	250	10	86.25 abcde	89.75 defgh1	71.75 efgh	50.00 bcdef	35.00 def
1500	200	,	88.25 abcde	83.00 fgh11	80,00 cdefg	0.00 h	0.00
1500	200	\$	71.00 cdef	92.75 abcdef	78.25 bcdefg	70.00 abc	56.67 bcd
1500	200	10	78.25 bcde	83.75 ghtj	87.25 abcdef	55.00 abcde	51.67 cd
1500	1000		88.25 abcde	87.50 efgh1	96.00 abc	36.66 def	33.33 def
Control	1	I	0.00	1.500 1	5.25 k	0°00 h	0.00

Rean separation within columns at 5% level using L. S. D.

TABLE 2: Percent shoot damage of deciduous nursery stock sprayed with ethephon, endothall, and cycloheximidey, evaluated during May, 1976.*

	CONCENTRATIONS (ppm)	(mdd)		TEST 1		TES	TEST 2
Ethephon	Endothal1	Cycloheximide	Red Delicious	Wine sap	Hopa Crubapple	Apple Seedlings	Pear Seedlings
250	259	5	0.75 g	48.75 defgh	4.25 bcd		
250	200	\$	34.66 cdefg	81.00 abcde	11.25 abcd	6.6	54.82
200	250	\$	70.00 abcd	46.25 efgh1	3.33 cd		
200	200	t	7.00 fg	3.75 Jk1	D.00 d		
200	200	v	78.75 abc	67.50 abcdefg	5.00 bcd	15.60	75.75
200	1000	ć	76.25 abc	46.25 efghijk	15.00 abcd	14.80	91.50
1000	250	S	72.50 abcd	25.00 fghijkl	1.67 cd		
1000	200	·	6.67 efg	26.25 ghijkl	2,50 cd		
1000	200	s	76.67 abcd	72.50 abcdef	30.00 ab	17.80	47.90
1000	1000	î	100.00 a	73.75 ubcde	8.33 bcd	11,10	
1500	250	ึง	85.00 abcd	8.75 hijki	1.25 d		
1500	200	í	48.33 abcdef	21.25 ghijkl	7.50 bed		
1500	200	'n	45.00 cdefg	98.75 a	16.67 abcd		
1599	1000	t	72.50 abcd	95.00 abc	40.00 а		
Control			0.00 g	0.00 1	D.00 d		

* Mean separation within columns at 5% level by L. S. D.

y Plants were sprayed during October, 1975.

 $^{\rm Z}{\rm No}$ 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

 $\mathbf{z}_{\text{Numbers}}$ below each plant indicate the concentrations in ppm of ethephon, endothall, and cycloheximide, applied.



CONTROL

CONTROL

250-250-10 500-0-10

250-500-10

500-250-10

FIGURE 1

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APPENDIX

Pear Seedlings 6.67 bcde 3.33 cde 8.33 abc 3.33 cde 3.33 def 8.33 abc 1.67 ef 3.33 cde 0.00 f 0.00 f 1.67 ef 10.00 ab 5.00 bcd 0.00 f 0.00 f 0.00 f 0.00 f € 00.0 0.00 f 0.00 f 0.00 f 0.00 f 0.00 f 15.67 a 0.00 f 0.00 f 0.00 f 0.00 f J. 00 .C 0.00 f 0.00 f TEST 2 Apple Seedlings 2.50 abo 5.00 a 3.33 ab 1.67 bc 3.33 ab 1.67 bc 5.00 ab 5.00 ab 5.00 a 5.00 a 0.00 c 5.00 a 5.00 ab 0.00 c 5.00 a 5.00 a 5.00 a 5.00 ab 0.00 c 5.00 a 0.00 c 0.00 c 0.00 c 5.00 a 5.00 a 5.00 a 0.00 APPENDIX 1: Percent shoot damage on deciduous nursery stock sprayed with ethephon, endothall, & cycloheximide in October, 1975, xy 0.00 Hopa Crobapple 4.00 abcd 3.50 cde 2.75 bcd 4.75 abc 0.00 e 1.25 de 6.50 ab 0.00 e 0.00 e 0.00 € 0.00 e 1.75 e 0.00 e 0.00 e 0.00 e 1.00 € 0.00 e 0.25 e 0.00 e 0.00 e 0.00 1.0 6 0.00 e 1.0 e 0.00 0.00 00.0 0.00 5.50 abcdef 4.25 abcdef TEST 1 4.50 cdefg 5.75 abcde 3.25 cdefg 4.25 cdefg 5.00 bcdef 5.25 bcdef 3.25 defgh 4.25 cdefg Winesap 2.75 efgh 6.75 abcd 7.20 abc 8.75 abc 2.50 fgh 1.25 gh 10.59 ab 0.00 h 10.75 ab 0.75 h 0.00 h 0.75 h 0.00 h 0.00 h 0.00 h 0.00 % 0.00 h 0.0 h 0.0 н 11.0 a 10.50 cdefg Red Delletous 3.800 efg 5.75 defg 8.25 defg 4.500 efg 10.75 cdef 6.00 efg 3.25 efg 1.75 efg 5.00 efg 2.00 efg 7.00 efg 2.33 efg 2.75 efg 0.00 3.00 efg 26.50 bcd 3.00 efg 5.75 efg 0.75 fg 2.75 efg 3.75 efg 0.00 g 1.00 fg 15.00 cde 0.00 fg 27.00 bc 56.25 a 18.75 ab 6.25 ab Cycloheximide CONCENTRATIONS (DPm) Endothall 1000 250 250 500 500 500 1000 250 Control 1000 1000 1000 1000 1500 1500 500 500 500 500 500 000 1000 1000 1000 1500 1500 1500 1500 1500

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

YDamage was evaluated during October, 1975.

APPENDIX 2: Percent plant damage of deciduous nursery stock sprayed with chtephon, endothall. and cycloheximide and evaluated during May, 1976.

Endoctivil 1 Cyclobroximide Red Deliticiuus Vilnescip Hopa Crabapple		CONCENTRATIONS	(mdd)		TEST 1		TES	TEST 2
	Ethephon	Endethal1		Red Delicious	Winesap	Hopa Crabapple	Apple Seedlings	Pear Seedlings
10 0.00 g 1,25 k1 0.00 d 250 5 0,75 g 48,75 de/gh 4,25 bcd 250 5 36,00 bcdefe 7,50 bcd 7,50 bcd 500 5 36,00 bcdefe 7,50 bcd 11.25 abcd 500 10 36,00 bcdefe 11.25 abcd 21,25 abc 5 31,23 abcdef 31,51 k1 0.00 d 250 10 0.00 g 0.00 1 1.05 d 250 10 10,00 kc 45,25 efgl 3.13 cd 250 10 11,07 defg 46,25 efgl 3.13 bcd 250 1 11,07 defg 46,25 efgl 3.13 bcd 250 1 11,07 defg 3.13 bcd 3.50 bcd 250 1 10 11,07 defg 46,25 efgl 3.50 bcd 250 1 10 10.00 g 3.13 bcd 3.50 bcd 250 1 10 10.00 g 3.50 bcd 3.50 bcd 250	250	ŀ	5	0.00 8	0.00 1	P 00.0		
250 5 0.75 g 48.75 defgh 4.25 bed 250 5 36.00 bedefg 50.00 cedefgh 7.50 bed 500 5 36.60 bedefg 50.00 cedefgh 7.50 bed 500 10 63.33 abede 92.50 abed 21.25 abe 5 51.75 abede 21.25 abe 21.50 bed 250 10 0.00 g 46.25 efgh 7.50 bed 250 10 31.77 defg 46.25 efgh 7.50 bed 500 - 7.00 fg 47.25 efgh 7.50 bed 500 - 7.00 fg 45.25 efgh 7.50 bed 500 - 7.00 fg 45.25 efgh 3.00 bed 500 - 7.00 fg 45.25 efgh 3.00 bed 500 - 70.23 abe 46.25 efgh 3.00 bed 500 - 70.23 abe 46.25 efgh 3.00 bed 500 - 70.23 abe 46.25 efgh 3.00 bed 500 - 70.50 efg	250	-	10	0.00	1.25 kl	0.00 d		
250 10 36.00 bedeff 50.00 celefgh 7.50 bed 500 5 36.00 bedeff 81.00 mbede 11.25 abcd 10 0.00 g 92.50 abcd 21.25 abcd 10 0.00 g 0.00 1 1.60 d 250 2 0.00 g 0.00 1 1.60 d 250 10 31.67 defg 46.25 efgh1 3.33 ed 250 - 7.00 abcd 46.25 efgh1 7.50 bed 250 - 7.00 abcd 46.25 efgh1 7.50 bed 250 - 7.00 abcd 5.00 bed 5.00 bed 250 - 7.27 abc 67.50 abcdefgh 3.13 bed 250 - 10 0.00 fg 3.37 efgh1 5.00 bed 250 - 10 0.00 fg 3.37 efgh1 1.60 abcd 250 5 7.2.73 abc 5.00 fgh13k1 5.00 bed 250 10 65.00 abcd 25.00 fgh13k1 5.00 d 250 <t< td=""><td>250</td><td>250</td><td>\$</td><td>0.75 €</td><td>48.75 defgh</td><td>4.25 bcd</td><td></td><td></td></t<>	250	250	\$	0.75 €	48.75 defgh	4.25 bcd		
500 5 34.66 cabf g 81.00 abcd d 11.25 abcd 500 10 63.33 abcdef 92.50 abcd 21.25 abcd 10 0.00 abcd 92.50 abcd 21.25 abcd 250 5 70.00 abcd 46.25 etght 3.33 cd 250 10 31.67 detg 46.25 etght 3.33 cd 250 - 70.00 abcd 46.25 etght 3.33 cd 250 - 70.00 fg 3.75 Jkl 3.33 cd 250 - 70.00 fg 3.75 Jkl 0.00 d 250 - 70.00 g 3.75 Jkl 0.00 d 250 - 70.00 g 3.75 Jkl 1.00 d 250 - 70.00 g 2.70 gbdl 3.00 bcd 250 - 70.00 g 2.20 gbcd	250	250	10	36.00 bcdefg	50.00 cdefgh	7.50 bcd	7.6	
500 10 63.33 ahcdef 92.50 abrd 21.25 abc 5 51.25 abcdef 1.35 jkl 0.00 d 250 5 70.00 abcd 66.25 efghl 1.60 d 250 9 70.00 abcd 66.25 efghl 31.30 cd 250 - 7.00 fg 31.75 kll 31.35 cd 500 - 7.00 fg 31.75 kll 31.35 cd 500 - 7.00 fg 31.75 kll 31.35 bcd 1000 - 7.00 fg 31.75 kll 31.30 bcd 5 7.75 abc 67.25 efghljk 35.30 bcd 5 7.75 abc 37.35 bcd fghl 35.30 bcd 5 7.75 abc 37.35 bcd fghl 35.30 bcd 250 5 7.75 abcd fghl 35.00 bcd 35.00 bcd 250 5 7.75 abcd fghl 35.00 bcd 35.00 bcd 250 5 7.75 abcd fghl 35.00 bcd 35.00 bcd 250 5	250	200	S	34.66 cdefg	81.00 abcde	11.25 abcd	6.9	54.82
250 51.25 abcdef 3.75 jkl 0.00 d 250 5 70.00 abcd 40.52 efghl 3.13 cd 250 10 31.67 defg 46.25 efghl 3.13 cd 250 10 31.67 defg 46.25 efghl 3.13 cd 500 - 7.00 fg 3.75 kl 5.30 bcd 500 - 7.6.75 abc 67.50 abcdfg 5.00 bcd 500 - 7.6.75 abc 66.75 efghljk 15.00 abcd 5 7.75 abc 66.75 efghljk 15.00 abcd 5 7.25 abc 66.25 efghljk 15.00 abcd 5 7.25 abcd 5.00 bcd 15.00 abcd 250 7.6.67 abcd 25.00 fghljkl 5.00 bcd 250 10.00 abcd 17.5 abcde 8.33 bcd 250 10.00 abcd 17.5 abcde 8.33 bcd 5 10.00 g 17.5 abcde 8.33 bcd 5 10.0	250	200	10	63.33 abcde	92.50 abcd	21.25 abc		6.04
10 0.00 g 0.00 1 1.60 d 250 5 70.00 abed 46.25 erght 3.13 ed 250 10 71.00 abed 46.25 erght 75.0 bed 250 5 78.75 abe 67.50 abederg 5.00 bed 250 10 88.33 abe 67.50 abederg 5.00 bed 250 10 88.33 abe 67.50 abederg 5.00 bed 250 10 65.00 abederg 75.00 abederg 75.00 bed 250 10 65.00 abederg 75.50 bederg 75.00 bed 250 10 65.00 abed 75.00 fgiljkl 75.00 bed 250 10 65.00 abed 75.50 fgiljkl 75.00 bed 250 10 65.00 abed 75.50 abederg 75.00 abederg 75.50 abederg 75.00 abeder	200	l	v	51.25 abcdef	3.75 Jk1	P 00.0		
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0.00 g 0.00 l	1500	1000	,	72.50 abcd	95.00 abc	40.00 a		-
1 (1-02)(1-04)	Control			0.00	0.00 1	0.00 d		

No dumage was rated 0% and complete kill was rated 100%, Plants were sprayed during October, 1975

**Rean separation within columns at 5% level by U.S.D.

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

by

RAMASWAMY CHIKKANAYAKANAHALLI ADISESH

B. Sc. (Ag), University of Agricultural Sciences Bangalore, India 1973

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fullfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Horticulture and Forestry Kansas State University Manhattan, Kansas 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.