FIVE YEARS' RESULTS WITH PRE-STORAGE CHEMICAL DEFOLIATION OF DECIDUOUS NURSERY STOCK[1]

FENTON E. LARSEN
Washington State University
Pullman, Washington

The use of chemicals to defoliate nursery stock dates back to at least 1940, when Milbrath, *et al.*, (7), advocated the use of ethylene gas for defoliating roses in storage. a method that apparently works well but which has disadvantages.

The need for early defoliation in the nursery to allow earlier digging of stock has undoubtedly existed for years in many areas. Hand-stripping is a common, but very expensive method of leaf removal. Other non-chemical methods (sweating in pits, use of animals, etc.) have been used but all have serious limitations.

Chemically-induced defoliation prior to digging and storage is potentially the most promising method of leaf removal, but an entirely satisfactory chemical treatment for a wide variety of plants has not been found. A number of chemicals have been tried (3,4 6,8,9,10,11) by various workers, but only a few have been useful and none has received commercial acceptance. A naturally occurring growth regulator, such as Abscisin II (1), seems potentially to be the ultimate answer, but present information indicates that it, too, lacks the features of an effective nursery stock defoliant (2) in spite of considerable speculative publicity to the contrary.

An effective defoliant for deciduous woody nursery stock should cause 50% or more leaf fall in 2-3 weeks and any remaining leaves should be loose enough to drop during digging and handling prior to storage. Little or no bud or bark damage can be tolerated, and the plant must grow normally following transplanting.

During the past five years, with the cooperation of several members of the Washington State Nursery Association, a number of chemicals and chemical combinations have been tested for nursery stock defoliation in central Washington. Various commercial defoliants (developed primarily for field crops) and miscellaneous chemicals were tried. The results of these tests are reported here.

MATERIALS AND METHODS

Sprays were applied at commercial nurseries in central Washington using a portable power sprayer operating at approximately 150 psi. Sprays were applied to runoff, using rates based on the manufacturer's suggestions when available. At weekly intervals following treatment, until the plants were dug and stored by the nurseryman, the percentage defoliation was visually determined. Following winter storage, the plants

[1]Scientific paper 3034, College of Agriculture, Washington State University Work was conducted under project 1690 Financial support was given by C and O, Heath, May, Mt Arbor, Milton, Pacific Coast and VanWell Nurseries.

were replanted for observation in commercial plantings or at Pullman in test plots. In all years, except 1966, single plots of 5 plants or more were treated for each cultivar. During 1966, duplicate plots of 3 or more plants were used.

In 1962, treatments were started September 28 and repeated 3 times at weekly intervals on previously untreated plants. In 1963, treatments were applied on October 17 and 24. In 1964, applications were made on October 15 and 22 at low concentrations on the same plants and compared with single higher doses. In the years following 1964, only one application per plot was made, but treatments were applied twice, a week apart, on previously untreated plots. In 1965, sprays were applied on October 8 and 15, and in 1966 on October 13 and 20.

Throughout the text, concentrations are expressed in percentages of the formulation or chemical as received and not active ingredients or absolute amounts. Percentages are calculated on volume for liquids and weight for dry materials.

RESULTS AND DISCUSSION

1962:

During 1962, 10 chemicals were used on 13 cultivars. The results from only two chemicals and the last two treatment dates are given in Table 1. These chemicals were DEF (S, S, S-tributyl phosphorotrithioate) and Folex (tributyl-phosphorotrithioite), both commercial defoliants and very similar in composition. Other chemicals used, which were unsatisfactory at the rates used and under the conditions of this trial, are listed in Table 2. The two earliest spraying dates (September 28 and October 5) resulted in excessive damage with all chemicals.

One Washington nursery used DEF at about 1% on a moderate scale with success for one or two years prior to 1962. Two nurseries used this material extensively in 1962 and both reported some unfavorable results. As noted in Table 1, a 1% concentration may be too high under some conditions with some plants.

Some chemicals listed in Table 2 might be satisfactory if used at lower rates, but with the exception of Glytac EC plus oil, all caused extensive damage.

1963:

In 1963, 7 chemicals were used on 10 cultivars. Those that produced the best results are listed in Table 3. UC 20299 was the poorest of these chemicals. Damage with most chemicals was minor compared to the previous year. Potassium iodide (KI) and aminotriazole were generally unsatisfactory because of excessive damage, and Cadox was generally ineffective at the rates used (Table 2). In spite of the injury with KI, a favorable response encouraged further work.

Table 1. Percent defoliation induced by chemicals applied in the nursery to several deciduous woody plants (1962).[1]

Plant	Treatment date (Oct)	Chemical and concentration: DEF[2] 0.75%	DEF 1.00%	DEF 1.25%	Folex[2] 0.75%	Folex 1.00%	Folex 1.25%
'Edwards'	12	100 (4)[3]	100 (4)	100 (4)	100 (4)	100 (4)	100 (4)
plum	19	100 (3)	100 (3)	100 (3)	100 (3)	100 (3)	100 (3)
'Early Italian'	12	———	———	———	———	———	———
prune	19	95 (3)	95 (3)	95 (3)	100 (3)	100 (3)	100 (3)
'Perfection'	12	100 (3)	100 (3)[4]	100 (2)[4]	100 (2)	100 (2)[4]	100 (2)[4]
apricot	19	100 (2)	100 (2)[4]	100 (2)[4]	100 (2)	100 (2)[4]	100 (2)[4]
'Bartlett'	12	100 (3)	100 (3)	100 (3)	100 (3)	100 (3)	100 (3)[4]
pear	19	100 (3)	100 (3)	100 (3)	100 (3)	100 (3)	100 (3)[4]
'Anjou'	12	———	———	———	———	———	———
pear	19	100 (3)	100 (3)[4]	100 (3)[4]	100 (3)	100 (3)[4]	100 (3)[4]
'Winesap'	12	100 (4)	100 (4)[4]	100 (3)[4]	100 (4)	100 (4)[4]	100 (3)
apple	19	100 (3)	100 (3)[4]	100 (3)[4]	100 (3)	100 (3)[4]	100 (3)[4]
'Rome Beauty'	12	———	———	———	———	———	———
apple	19	80 (3)	80 (3)	80 (3)[4]	50 (3)	50 (3)	50 (3)[4]
'Anthony Waterer'	12	———	———	———	———	———	———
spiraea	19	20 (3)	20 (3)	20 (3)	20 (3)	30 (3)[4]	40 (3)[4]
Weigela rosea	12	———	———	———	———	———	———
	19	20 (3)	30 (3)	30 (3)	20 (3)	30 (3)	30 (3)
French crab	12	———	———	———	———	———	———
sldg	19	60 (3)	60 (3)	60 (3)	80 (3)	80 (3)	80 (3)
French pear	12	———	———	———	———	———	———
sldg.	19	50 (3)	60 (3)	75 (3)	75 (3)	75 (3)	75 (3)
Pyrus calleryana	12	———	———	———	———	———	———
sldg.	19	0 (3)	0 (3)	0 (3)	0 (3)	0 (3)	0 (3)
Prunus mahaleb	12	———	———	———	———	———	———
sldg.	19	75 (3)	75 (3)	75 (3)	70 (3)	80 (3)	100 (2)

[1]Defoliation of controls was nil on November 9, four weeks following the first application except for 'Perfection' apricot which had lost 20% of its leaves
[2]Concentration calculated on the percentage of formulation used, not active ingredient (6#/gal.) Dupont spreader-sticker used in addition at 1 pt/100 gal spray material
[3]Numbers in parentheses are the weeks required for the indicated percentage defoliation Plants usually dug by that time
[4]Concentration excessive under conditions of this trial, usually judged because of poor growth after replanting rather than damage prior to storage

Table 2. Miscellaneous chemicals used in defoliation trials but considered generally unsatisfactory at the indicated rates and under the conditions of these trials on deciduous woody nursery stock

CHEMICAL	CONCENTRATION[1]		
1962			
Endothal (3,6 endohexahydrothalate)	1.0%	1.5%	2.0%
TD 273 Harvest Aide	1.0	1.5	2.0
Endothal-TD 288 Harvest Aide	1.0	1.5	2.0
Ansar 138 (cacodylic acid)	0.12	0.24	0.36
Diquat (1:1 ethylene-2:2 dipyridylium dichloride)	1.125	0.25	0.50
Paraquat (1:1-dimethyl-4,4' dipryidylium *dichloride*)	0.125	0.25	0.50
Glytac EC (plus 10% Volck supreme oil)	0.125	0.25	0.375
Hydrogen cyanamid	0.60	1.20	1.80
1963			
Cadox (cadmium oxyquinolate)	0.12	0.24	0.36
Aminotriazole (3-amino-1,2,4-triazole)	0.12	0.24	0.36
Potassium iodide (KI)	0.60	1.20	1.80

[1]Concentration calculated on the percentage of the formulation used, not active ingredient

Table 3. Percent defoliation induced by chemicals applied in the nursery on two dates (October 17 and 24) to several deciduous wood plants. (1963)

Plant Treat Date (Oct)		'Red King' apple		'Bartlett pear		'Stewart Bartlett pear		'Daroga Red' peach		'Laroda' plum	
		17	24	17	24	17	24	17	24	17	24
Chemical	*Conc. (%)* [1]										
DEF	0.75	0 (4) [2]	0 (3) [3]	0 (4)	5 (3)	50 (4)	30 (3)	100 (3)	———	90 (4)	20 (3)
	1.00	0 (4) [2]	0 (3)	0 (4)	5 (3)	50 (4) [2]	50 (3) [2]	100 (3) [2]	———	90 (4) [2]	20 (3) [2]
	1.50	0 (4) [2]	0 (3)	0 (4)	5 (3)	50 (4) [2]	75 (3) [2]	100 (3) [2]	———	90 (4) [2]	20 (3) [2]
Nacconol NR[4] (plus 3% Volck Supreme *oil*)	1.00	0 (4)	0 (3)	10 (4) [2]	40 (3)	90 (4) [2]	100 (3)	50 (3)	75 (2)	10 (4)	20 (3)
	2.00	0 (4) [2]	0 (3) [2]	10 (4) [2]	40 (3)	90 (4) [2]	100 (3) [2]	50 (3)	95 (2)	10 (4)	20 (3)
	3.00	0 (4) [2]	0 (3) [2]	10 (4) [2]	40 (3) [2]	80 (4) [2]	100 (3) [2]	75 (3)	95 (2)	10 (4)	20 (3)
Hydrogen cyanamid	0.12	0 (4)	0 (3)	5 (4) [2]	20 (3)	50 (4) [2]	100 (3) [2]	70 (3)	90 (2)	20 (4)	10 (3)
	0.48	0 (4)	0 (3)	5 (4) [2]	20 (3)	50 (4) [2]	80 (3) [2]	70 (3)	75 (2)	20 (4)	25 (3)
	0.72	0 (4)	0 (3)	5 (4) [2]	20 (3) [2]	75 (4) [2]	100 (3) [2]	80 (3)	95 (2)	20 (4)	40 (3)
UC 20299	0.12	75 (4) [2]	0 (3)	0 (4) [2]	20 (3) [2]	25 (4)	25 (3)	80 (3)	95 (2)	10 (4)	20 (3)
	0.36	10 (4) [2]	0 (3)	0 (4) [2]	20 (3) [2]	5 (4) [2]	25 (3) [2]	90 (3)	60 (2)	10 (4)	20 (3)
	0.60	30 (4) [2]	0 (3)	0 (4) [2]	20 (3) [2]	5 (4) [2]	50 (3) [2]	90 (3)	60 (2)	10 (4)	20 (3)
NONE	———	0 (4)		5 (4)		50 (4)		35 (3)		10 (4)	

[1]Concentration calculated on a formulation basis, not active ingredient X-77 also used at 1 pint/100 gal
[2]Concentration excessive under conditions of this trial, usually judged because of poor growth following replanting rather than damage prior to storage
[3]Figures in parenthesis are the weeks required for the indicated percentage defoliation Plants usually dug by that time
[4]An alkylarylsulfonate.

Table 3 (continued)

Plant		French crab sldg		Bartlett pear		P mahaleb sldg		Eva Rathke weigela		Spiraea billiardii	
DEF	0 75	20 (4)	10 (3)	90 (4)	85 (3)	60 (5)	60 (4)	95 (5) [2]	40 (4) [2]	40 (5)	30 (4)
	1 00	20 (4) [2]	25 (3)	100 (4) [2]	95 (3)	70 (5)	50 (4)	95 (5) [2]	90 (4) [2]	40 (5)	30 (4)
	1 50	50 (4) [2]	50 (3)	100 (4) [2]	95 (3)	40 (5)	40 (4)	95 (5) [2]	90 (4) [2]	40 (5) [2]	30 (4) [2]
Nacconol	1 00	0 (4) [2]	0 (3)	60 (4) [2]	25 (3)	100 (5)	90 (4)	50 (5) [2]	15 (3)	90 (5)	95 (4)
NR[4] (plus	2 00	0 (4) [2]	0 (3)	70 (4) [2]	25 (3)	100 (5) [2]	50 (4)	50 (5) [2]	15 (3)	60 (5)	95 (4)
3% Volck	3 00	0 (4) [2]	0 (3) [2]	70 (4) [2]	80 (3)	90 (4) [2]	90 (4)	50 (5) [2]	15 (3)	90 (5) [2]	100 (3) [2]
Supreme oil)											
Hydrogen	0 12	0 (4)	0 (3)	40 (4)	25 (3)	90 (4)	80 (4)	50 (5)	30 (4)	30 (5)	20 (4)
cyanamid	0 48	0 (4)	10 (3)	40 (4)	25 (3)	75 (5)	80 (4)	50 (5)	30 (4)	60 (5)	20 (4)
	0 72	0 (4)	25 (3)	95 (4)	90 (3)	95 (5)	95 (4)	50 (5) [2]	30 (4)	90 (5)	60 (4)
UC 20299	0 12	20 (4)	0 (3)	50 (4)	75 (3)	30 (5) [2]	20 (4)	20 (5) [2]	10 (4) [2]	100 (5)	100 (4)
	0 36	20 (4)	0 (3)	50 (4) [2]	60 (3)	50 (5) [2]	20 (4)	20 (5) [2]	10 (4) [2]	25 (5)	50 (4)
	0 60	20 (4)	0 (3)	100 (4) [2]	40 (3)	40 (5) [2]	20 (4)	20 (5) [2]	10 (4) [2]	25 (5)	50 (4)
NONE	———	0 (4)		25 (4)		10 (5)		5 (5)		0 (5)	

1964:

In 1964, 7 chemicals—or combinations of chemicals—were applied on October 15 and 22 on 11 cultivars, and single and double applications (on the same plants) were compared (Table 4). Damage was almost nil, occurring only on weigela, 'Rome' apple, and *P. mahaleb* seedlings. The damage to 'Rome' apple was not apparent until after storage and replanting. The most satisfactory chemical treatments were KI in combination with Nacconol NR (an alkylarylsulfonate) or with DEF. These combinations frequently resulted in faster defoliation than when these chemicals were used separately. Repeat applications of low and medium rates were usually more satisfactory than single low, medium, or high rates. The time required for complete defoliation (where achieved) under undisturbed conditions varied from 1 to 6 weeks. The figures with 'Yellospur', 'Hi-Early', 'Rome' apples and 'Italian' prune are low because of early digging (2 and 3 weeks after treatment). An additional week in the field at the stage they were dug would usually increase defoliation considerably.

1965:

In 1965, 15 chemicals or chemical combinations were used on 14 cultivars applied on October 8 and 15. Damage was more severe than the previous year, especially with the earlier application date. However, both dates were earlier than in 1964; this undoubtedly accounts for a good portion of the damage. The 5 years' data presented here indicate that plants become more resistant to damage and easier to defoliate as dormancy approaches, and that more damage occurs from treatments made prior to October 15, even though growth and conditions varied considerably from year to year.

The most satisfactory materials were KI, KI + alanine, Bromodine (a bromine-iodine complex) and DEF. Other materials were not as effective and/or caused more damage. *Pyrus calleryana*, French crab, and 'Bartlett' pear seedlings were not completely defoliated without damage by any treatment. Some cultivars were more subject to damage than others, especially 'Bartlett' pear. The time required for complete defoliation with undisturbed conditions varied from 2 to 5 weeks, depending on the plant.

Table 4. Percent defoliation induced by chemicals as a result of single and double[1] spray applications (October 15 and 22) applied in the nursery to several deciduous woody plants. (1964).

Plant Treat Date (Oct)		'Yellospur' apple		'Hi-Early apple		'Rome apple		'Italian prune		'Bartlett' pear		'Montmorency' cherry	
		15	22	15	22	15	22	15	22	15	22	15	22
Chemical	Conc. (%)												
KI	0.15	5 (3)[2]	15 (2)	40 (3)	40 (2)	5 (3)	5 (2)	80 (3)	95 (2)	100 (4)	100 (5)	100 (5)	100 (4)
	0.3	25 (3)	42 (2)	40 (3)	40 (2)	5 (3)	5 (2)	95 (3)	100 (2)	100 (5)	100 (3)	100 (3)	100 (2)
	0.6	20 (3)	30 (2)	30 (3)	0 (2)	10 (3)	0 (2)	95 (3)	65 (2)	100 (4)	100 (4)	100 (3)	100 (3)
KI + DEF (0.25%)	0.15	40 (3)	65 (2)	85 (3)	90 (2)	0 (3)	0 (2)[3]	85 (3)	95 (2)	100 (4)	100 (3)	100 (3)	100 (1)
	0.3	25 (3)	50 (2)	95 (3)	100 (2)	0 (3)	0 (2)[3]	95 (3)	100 (2)	100 (4)	100 (3)	100 (3)	100 (2)
	0.6	65 (3)	95 (2)	40 (3)	0 (2)	0 (3)	0 (2)[3]	100 (3)	60 (3)	100 (3)	100 (3)	100 (3)	100 (2)
KI + NAC NR (0.5%)	0.15	25 (3)	100 (2)	15 (3)	90 (2)	0 (3)	0 (2)[3]	95 (3)	100 (2)	100 (5)	100 (4)	100 (5)	100 (4)
	0.3	30 (3)	100 (2)	35 (3)	50 (2)	0 (3)	0 (2)[3]	100 (3)	100 (2)	100 (4)	100 (3)	100 (4)	100 (2)
	0.6	0 (3)	25 (2)	20 (3)	0 (2)	0 (3)	0 (2)	100 (3)	65 (2)	100 (4)	100 (4)	100 (3)	100 (2)
KI + W Sulfur (0.5%)	0.15	15 (3)	10 (2)	70 (3)	80 (2)	5 (3)	5 (2)	20 (3)	50 (2)	100 (4)	100 (3)	100 (3)	100 (1)
	0.3	0 (3)	25 (2)	80 (2)	85 (2)	5 (3)	5 (2)	90 (3)	90 (2)	100 (5)	100 (3)	100 (5)	100 (3)
	0.6	0 (3)	30 (2)	40 (3)	0 (2)	5 (3)	0 (2)	100 (3)	15 (2)	100 (4)	100 (4)	100 (3)	100 (2)
DEF	0.25	10 (3)	10 (2)	10 (3)	10 (2)	5 (3)	5 (2)	15 (3)	70 (2)	100 (5)	100 (4)	100 (6)	100 (3)
	0.50	15 (3)	25 (2)	10 (3)	10 (2)	5 (3)	5 (2)	70 (3)	80 (2)	100 (6)	100 (4)	100 (4)	100 (3)
	1.00	0 (3)	0 (2)	10 (3)	10 (2)	5 (3)	0 (2)	90 (3)	50 (2)	100 (6)	100 (4)	100 (5)	100 (4)
NAC NR	0.50	5 (3)	30 (2)	10 (3)	10 (2)	0 (3)	0 (2)	85 (3)	80 (2)	100 (6)	100 (5)	100 (5)	100 (4)
	1.00	40 (3)	40 (2)	10 (3)	10 (2)	0 (3)	0 (2)	85 (3)	90 (2)	100 (5)	100 (4)	100 (5)	100 (4)
	2.00	40 (3)	0 (2)	10 (3)	10 (2)	0 (3)	0 (2)	85 (3)	15 (2)	100 (5)	100 (4)	100 (5)	100 (4)
Defolate	0.22	25 (3)	25 (2)	40 (3)	40 (2)	0 (3)	0 (2)	25 (3)	70 (2)	100 (5)	100 (3)	100 (4)	100 (3)
	0.24	25 (3)	50 (2)	40 (3)	40 (2)	0 (3)	0 (2)	30 (3)	60 (2)	95 (5)	100 (4)	100 (4)	100 (3)
	0.48	45 (3)	0 (2)	30 (3)	0 (2)	0 (3)	0 (2)	70 (3)	20 (2)	100 (5)	100 (4)	100 (3)	100 (3)
NONE	———	0 (3)	0 (2)	0 (3)	0 (2)	0 (3)	0 (2)	15 (3)	15 (2)	100 (6)	100 (5)	100 (6)	100 (5)

[1]The figures for October 15 were all a result of single applications while the low and medium figures for October 22 were a result of treatment of the same plants on both dates with the same concentration

[2]Numbers in parenthesis are the weeks required for the indicated percentage defoliation preceeding the parenthesis. Plants usually dug by that time

[3]Four to six inches damage on some branch tips, obvious only after replanting and commencement of growth

[4]Terminals damaged at storage time

Table 4 (continued)

		'Ev[1] Rathke weigela		Spiraea billiardii		P mahaleb sldg		'Bartlett pear sldg		French crab sldg	
		15	22	15	22	15	22	15	22	15	22
KI	0 15	10 (6)	70 (5)	60 (6)	100 (4)	100 (5)	100 (2)	90 (5)	100 (4)	5 (5)	5 (4)
	0 3	60 (6)	85 (5) [4]	95 (4)	100 (2)	90 (5)	100 (4)	20 (5)	40 (4)	5 (5)	10 (4)
	0 6	15 (6)	90 (5)	70 (6)	60 (5)	100 (5)	100 (5)	60 (5)	40 (4)	20 (5)	50 (4)
KI + DEF (0 25%)	0 15	40 (6)	50 (5) [4]	100 (6)	100 (2)	20 (6)	95 (5)	70 (5)	———	10 (5)	———
	0 3	35 (6)	80 (5) [4]	100 (6)	100 (3)	25 (6)	100 (4)	60 (5)	———	50 (5)	———
	0 6	20 (6)	70 (5)	80 (6)	95 (5)	100 (5)	100 (4)	100 (5)	———	85 (5)	———
KI + NAC NR (0 5%)	0.15	15 (6) [4]	90 (5)	80 (6)	100 (5)	100 (5)	100 (4)	80 (5)	90 (4)	5 (5)	10 (4)
	0 3	70 (6) [4]	70 (5) [4]	90 (6)	100 (4)	100 (5)	100 (4)	80 (5)	70 (4)	20 (5)	30 (4)
	0 6	30 (6)	75 (5) [4]	95 (6)	95 (5)	100 (5) [4]	100 (4)	80 (5)	35 (4)	40 (5)	30 (4)
KI + W Sulfur (0 5%)	0 15	5 (6)	60 (5)	50 (6)	100 (5)	25 (6)	25 (4)	25 (5)	20 (4)	30 (5)	40 (4)
	0 3	15 (6)	90 (5)	100 (5)	100 (4)	80 (6)	100 (5)	20 (5)	50 (4)	20 (5)	60 (4)
	0 6	10 (6)	80 (5)	70 (6)	75 (5)	100 (5)	100 (5)	40 (5)	65 (4)	40 (5)	25 (4)
DEF	0 25	5 (6)	25 (5)	50 (6)	50 (5)	100 (6)	100 (5)	15 (5)	15 (4)	0 (5)	5 (4)
	0 50	25 (6)	65 (5)	40 (6)	90 (5)	30 (6)	25 (5)	20 (5)	30 (4)	15 (5)	5 (4)
	1 00	5 (6)	30 (5)	40 (6)	40 (5)	20 (6)	25 (5)	50 (5)	20 (4)	20 (5)	5 (4)
NAC NR	0 50	25 (5)	5 (4)	70 (6)	90 (5)	45 (6)	80 (5)	10 (5)	15 (4)	5 (5)	5 (4)
	1 00	25 (6)	10 (5)	70 (6)	100 (5)	20 (6)	30 (5)	20 (5)	20 (4)	10 (5)	10 (4)
	2 00	30 (6)	5 (4)	70 (6)	60 (5)	90 (6)	40 (5)	20 (5)	20 (4)	10 (5)	5 (4)
Defolate	0 12	5 (6)	5 (5)	30 (6)	95 (5)	25 (6)	20 (5)	40 (5)	15 (4)	15 (5)	20 (4)
	0 24	15 (6)	10 (5)	60 (6)	90 (5)	10 (6)	10 (5)	15 (5)	60 (4)	50 (5)	35 (4)
	0 48	10 (6)	5 (5)	30 (6)	25 (5)	75 (6)	10 (5)	85 (5)	60 (4)	75 (5)	35 (4)
NONE	———	5 (6)	5 (5)	20 (6)	20 (5)	30 (6)	30 (5)	5 (5)	5 (4)	5 (5)	5 (4)

Table 5. Percent defoliation induced by chemicals applied in the nursery to several deciduous woody plants (1965).

Chemical	Conc (%)	Barkley Red Rome' apple		'Red Rome' apple		'Jonathan' apple		Idared' apple		'Winesap' apple	
Plant											
Treat date (Oct)		8	15	8	15	8	15	8	15	8	15
Potassium	0 2	90 (4) [2]	0 (3)	—	50 (3)	100 (4)	50 (3)	10 (5)	15 (4)	100 (4)	100 (3)
iodide (KI)	0 3	95 (4) [4]	35 (3)	—	40 (3)	100 (4) [4]	90 (3)	100 (5) [4]	80 (4)	100 (4)	100 (3) [4]
KI (0 3%)	1 5	----------	35 (3)	—	60 (3)	———	100 (3)	100 (5)	80 (4)	———	100 (3)
+b-alanine	2 0	———	60 (3)	—	60 (3)	———	100 (3)	80 (5) [4]	90 (4)	———	100 (3) [4]
KI (0 3%) +	0 5	100 (3) [4]	5 (3)	—	60 (3)	100 (4) [4]	70 (3)	90 (5)	20 (4) [4]	100 (3)	100 (3)
hexamethyl-	1 0	100 (4) [4]	5 (3) [4]	—	70 (3)	30 (4) [4]	85 (3)	10 (5)	50 (4) [4]	100 (4) [4]	100 (3)
entetramine											
(HMTA)											
KI (0 3%) +	1 0	35 (4)	5 (3)	—	20 (3)	75 (4)	50 (3)	40 (5)	20 (4)	100 (4)	100 (3)
Formaldehyde	1 5	25 (4)	5 (3)	—	35 (3)	70 (4)	40 (3) [4]	50 (5) [4]	60 (4)	100 (4)	100 (3)
b-alanine	2 0	———	5 (3)	—	60 (3)	———	30 (3)	10 (5)	15 (4)	———	80 (3)
HMTA	1 0	0 (4) [4]	5 (3)	—	10 (3)	30 (4) [4]	5 (3) [4]	5 (5) [4]	10 (4)	5 (4) [4]	70 (3) [4]
Formaldehyde	1 5	10 (4)	5 (3)	—	35 (3)	30 (4) [4]	40 (3)	50 (5)	50 (4)	20 (4) [4]	60 (3) [4]
Bromodine	2 0	80 (4)	55 (3)	—	80 (3)	50 (4)	95 (3)	65 (5) [4]	70 (4)	85 (4)	90 (3)
	3 0	100 (4)	85 (3)	—	60 (3)	100 (4)	100 (3)	100 (5) [4]	100 (4)	100 (4) [4]	95 (3) [4]
DEF	0 75	100 (4) [4]	100 (3)	—	100 (3)	100 (4)	100 (3)	100 (4)	35 (4)	100 (4) [4]	100 (3)
	1 0	100 (4) [4]	100 (3)	—	100 (3)	100 (3)	100 (3) [4]	100 (5) [4]	85 (4) [4]	100 (3)	100 (3)
Shedaleaf	0 36	65 (4)	70 (3)	—	95 (3)	100 (4) [4]	100 (3) [4]	50 (5)	60 (4)	80 (4) [4]	100 (3)
	0 48	90 (4) [4]	85 (3) [4]	—	100 (3)	100 (4) [4]	100 (3) [4]	50 (5) [4]	75 (4) [4]	**90 (4)** [4]	100 (3)
Defolate	0 24	60 (4)	45 (3)	—	75 (3)	70 (4) [4]	80 (3)	20 (5)	20 (4)	70 (4)	95 (3)
	0 36	75 (4)	45 (3)	—	100 (3)	100 (4)	85 (3)	35 (5)	60 (4)	90 (4)	100 (3)
Union 76-1	5 0	5 (4)	35 (3)	—	100 (3)	10 (4)	70 (3)	35 (5)	55 (4)	5 (4) [4]	50 (3)
	10 0	40 (4)	60 (3)	—	85 (3)	100 (4)	95 (3)	10 (5) [4]	85 (4) [43]	10 (4)	75 (3) [4]
Union 76-2	5 0	25 (4) [4]	50 (3)	—	75 (3)	50 (4)	90 (3)	5 (5) [4]	20 (4)	25 (4)	50 (3)
	10 0	40 (4) [4]	50 (3)	—	90 (3)	90 (4)	90 (3)	25 (5) [4]	70 (4) [3]	25 (4)	70 (3)
Union 76-3	5 0	70 (4) [4]	50 (3)	—	65 (3)	90 (4)	80 (3)	60 (5)	60 (4)	5 (4)	55 (3)
	10 0	85 (4) [4]	85 (3)	—	85 (3)	95 (4) [4]	95 (3)	60 (5) [4]	90 (4) [3]	65 (4)	90 (3)
Chipman	0 75	———	70 (3)	—	85 (3)	———	60 (3) [4]	15 (5)	55 (4)	———	100 (3)
2929	1 50	———	90 (3)	—	65 (3)	———	100 (3) [4]	35 (5) [4]	85 (4)	———	100 (3)
NONE	———	0 (4)		0 (3)		5 (4)		0 (5)		5 (4)	

[1]Concentration calculated on the percentage of formulation X-77 used in addition at 1 pint/100 gal
[2]Numbers in parenthesis are the weeks required for the indicated percentage defoliation Plants usually dug by that time
[3]Some terminals damaged at storage time
[4]Growth not comparable to control after replanting

Table 5. (Continued)

Chemical	Conc. (%)	'Sunglo' apricot		'Italian' prune		'Montmorency' cherry		'Bartlett' pear		Bartlet' pear sldg	
Plant Treat date (Oct)		8	15	8	15	8	15	8	15	8	15
Potassium	0 2	85 (5)	75 (4)	100 (3) [4]	100 (3)	——	100 (3)	100 (5) [4]	95 (4)	10 (5)	15 (4)
iodide (KI)	0 3	85 (5)	75 (4)	100 (3) [4]	100 (3)	——	100 (3)	100 (5) [4]	100 (4)	35 (5)	25 (4)
KI (0 3%)	1 5	85 (5)	95 (4)	———	100 (3)	——	100 (3)	100 (3)	100 (3)	———	30 (4)
+ b-alanine	2 0	85 (5)	100 (4)	———	100 (3)	——	100 (3)	100 (3) [4]	100 (3)	———	40 (4)
KI (0 3%) +	0 5	50 (5)	70 (4)	100 (3)	100 (4)	——	100 (3)	100 (5) [4]	95 (4) [4]	70 (5) [4]	30 (4)
HMTA	1 0	50 (5) [4]	55 (4)	80 (5)	100 (4)	——	100 (3)	40 (5)	95 (4) [4]	75 (5)	40 (4)
KI (0 3%) +	1 0	80 (5) [34]	85 (4) [4]	100 (5) [4]	100 (4)	——	100 (3)	100 (5) [4]	100 (4)	65 (5)	15 (4)
Formaldehyde	1 5	25 (5) [34]	90 (4) [4]	100 (5) [4]	80 (4) [4]	——	100 (3)	100 (5) [4]	100 (4) [4]	100 (4) [4]	50 (4) [4]
b-alanine	2 0	65 (5)	90 (4)	100 (4)	90 (4)	——	60 (3)	100 (5)	60 (4)	———	5 (4)
HMTA	1 0	100 (5) [4]	60 (4)	80 (5)	95 (4)	——	50 (3)	20 (5) [4]	40 (4)	5 (5)	5 (4) [4]
Formaldehyde	1 5	70 (5) [4]	80 (4) [4]	80 (5)	90 (4) [4]	——	30 (3)	100 (5) [4]	90 (4) [4]	80 (4) [4]	50 (4) [4]
Bromodine	2 0	70 (5)	100 (4)	100 (3)	100 (4)	——	100 (3)	100 (3)	100 (3)	50 (5)	40 (4)
	3 0	60 (5) [4]	100 (4)	100 (3)	100 (3)	——	100 (3)	100 (3) [4]	100 (3) [4]	70 (5) [4]	95 (4)
DEF	0 75	95 (5)	90 (4)	70 (5)	100 (4)	——	100 (3)	100 (5) [4]	100 (4)	25 (5)	35 (4)
	1 0	95 (5)	90 (4)	70 (5)	100 (4)	——	100 (3)	100 (5) [4]	100 (4) [4]	50 (5)	65 (4)
Shedaleaf	0 36	95 (5)	70 (4)	70 (5)	100 (4)	——	95 (3)	70 (5) [4]	80 (3) [4]	80 (5)	15 (4)
	0 48	95 (5)	80 (4)	70 (5)	100 (4)	——	100 (3)	60 (5) [4]	90 (4) [4]	90 (5)	80 (4)
Defolate	0 24	95 (5)	80 (4)	70 (5)	100 (4)	——	90 (3)	70 (5) [4]	80 (4) [4]	10 (5)	70 (4)
	0 36	95 (5)	85 (4)	70 (5)	100 (4)	——	100 (3)	75 (5) [4]	100 (4) [4]	50 (5)	90 (4)
Union 76-1	5 0	25 (5) [34]	60 (4)	100 (5)	100 (4)	——	10 (3)	30 (5) [4]	90 (4) [4]	0 (5) [4]	15 (4)
	10 0	50 (5) [34]	70 (4)	100 (5)	70 (4)	——	15 (3)	30 (5) [4]	90 (4) [4]	20 (5) [4]	50 (4) [4]
Union 76-2	5 0	40 (5)	65 (4)	100 (5)	70 (4)	——	15 (3)	25 (5) [4]	70 (4) [4]	20 (5) [4]	20 (4) [4]
	10 0	45 (5)	70 (4)	100 (5)	70 (4)	——	15 (3)	25 (5) [4]	75 (4)	25 (5) [4]	40 (4)
Union 76-3	5 0	90 (5)	90 (4)	95 (5)	80 (4)	——	5 (3)	30 (5) [4]	65 (4)	70 (5)	30 (4)
	10 0	90 (5) [4]	95 (4)	100 (5)	95 (4)	——	5 (3)	90 (5)	80 (4)	90 (5)	50 (4)
Chipman 2929	0 75	95 (5) [34]	100 (4)	100 (5)	100 (4)	——	75 (3)	95 (5) [4]	90 (4) [4]	10 (5)	5 (4)
	1 50	95 (5) [34]	100 (4)	90 (5) [4]	100 (4)	——	50 (3)	100 (5) [4]	90 (4)	10 (5)	10 (4)
NONE	———	60 (5)		20 (3)		5 (3)		35 (5)		0 (5)	

Table 5. (Continued)

Plant		P mahaleb sldg		French crab sldg		P calleryana sldg		Spiraea billiardii	
Treat date (Oct)		8	15	8	15	8	15	8	15
Chemical	Conc. (%)								
Potassium	0 2	——	95 (3)	5 (5)	5 (4)	20 (5)	20 (4)	——	90 (3)
iodide (KI)	0 3	——	100 (3)	5 (5)	10 (4)	30 (5)	10 (4)	——	90 (3)
KI (0 3%)	1 5	——	100 (3)	——	5 (4)	——	20 (4)	——	100 (2)
+ b-alanine	2 0	——	100 (3)	——	20 (3)	——	20 (3)	——	100 (2)
KI (0 3%) +	0 5	——	90 (3)	10 (5) [4]	0 (4)	10 (5)	30 (4)	——	95 (3)
HMTA	1.0	——	90 (3)	5 (5) [4]	5 (4)	20 (5)	10 (4)	——	100 (3)
KI (0.3%) +	1.0	——	40 (3)	5 (5) [4]	5 (4)	15 (5)	10 (4)	——	35 (3)
formaldehyde	1 5	——	50 (3) [4]	5 (5)	5 (4) [4]	20 (5)	20 (4)	——	15 (3)
b-alanine	2 0	——	5 (3)	——	0 (4)	——	15 (4)	——	100 (2)
HMTA	1 0	——	20 (3)	0 (5)	0 (4)	0 (5)	5 (4)	——	10 (3)
Formaldehyde	1.5	——	35 (3)	0 (5)	5 (4)	25 (5)	25 (4)	——	10 (3)
Bromodine	2.0	——	85 (3)	5 (5)	0 (4)	20 (5)	15 (4)	——	45 (3)
	3 0	——	50 (3)	25 (5) [4]	60 (4)	20 (5)	65 (4)	——	70 (3)
DEF	0 75	——	35 (3)	30 (5) [4]	5 (4)	15 (5)	25 (4)	——	60 (3)
	1 0	——	55 (3)	50 (5)	30 (4)	25 (5)	30 (4)	——	70 (3)
Shedaleaf	0 36	——	75 (3)	0 (5)	25 (4)	10 (5)	5 (4)	——	25 (3)
	0 48	——	85 (3)	40 (5)	20 (4) [4]	10 (5)	5 (4)	——	40 (3)
Defolate	0 24	——	75 (3)	5 (5) [4]	5 (4)	5 (5)	10 (4)	——	30 (3)
	0.36	——	70 (3)	5 (5)	5 (4)	5 (5)	15 (4)	——	40 (3)
Union 76-1	5 0	——	5 (3)	0 (5)	0 (4)	10 (5)	20 (4)	——	25 (3)
	10 0	——	50 (3)	0 (5)	0 (4)	30 (5)	35 (4)	——	20 (3)
Union 76-2	5 0	——	5 (3)	0 (5)	0 (4)	20 (5)	10 (4)	——	20 (3)
	10.0	——	30 (3)	0 (5)	0 (4)	15 (5)	20 (4)	——	20 (3)
Union 76-3	5 0	——	25 (3)	0 (5)	0 (4)	15 (5)	30 (4)	——	35 (3)
	10 0	——	70 (3)	0 (5)	0 (4)	25 (5)	45 (4)	——	50 (3)
Chipman 2929	0 75	——	55 (3)	0 (5)	0 (4)	20 (5)	35 (4)	——	35 (3)
	1.50	——	20 (3)	0 (5)	25 (4)	40 (5)	25 (4)	——	30 (3)
NONE	——	——	10 (3)		0 (5)		0 (5)		(5 (3)

1966:

In 1966, 7 chemicals, or chemical combinations, were used on 12 cultivars. Bromodine, KI, and KI plus Bromodine were the most satisfactory. The addition of alanine to KI did not help as much as the previous year.

Almost no injury was apparent at storage time, but many plots failed to grow properly after replanting, notably those of 'Chinook' cherry and 'Bartlett' pear. It is of interest to note that plants which were replanted in commercial plantings ('Red Winesap', 'Golden Delicious', and 'Hi-Early' Delicious apples), rather than in test plots, grew normally. This would indicate that handling, planting, and subsequent care may have been more conducive to good growth under commercial conditions and that defoliated plants may be more subject to adverse conditions than non-defoliated plants. This had been suspected in previous years, but had not been nearly as apparent. However, the evidence is far from conclusive, since comparable plants were not observed under both conditions. Plants in the test plots were not headed back as in commercial plantings and less growth stimulation would be expected. Moisture may have been less adequate in test plots because of somewhat shallower plantings. Another factor contributing to the difference observed may have been the physical condition of the stock at the time of treatment, although these plants had set terminal buds when treated. It is not known whether hand-stripped plants would respond in a similar way or if the chemicals were entirely responsible. It is possible that hand-stripped plants might respond similarily if defoliated too early.

Pyrus calleryana, French crab, and Bartlett pear seedlings showed little response to the defoliants by the time they were dug. An additional week would have helped considerably except with *P. calleryana*, which did not respond satisfactorily to any treatment during the course of the experiments.

Interesting data was collected, although not presented here, to show that it would not be necessary to wait for complete defoliation in the field prior to digging. It was noted that plots showing as little as 10% defoliation at digging time could be 100% defoliated after digging, bundling, loading, and transporting to the storage. Thus, it would only be necessary to wait for partial defoliation, if the remainder of leaves was loose, prior to digging.

Table 6 Percent defoliation[1] induced by chemicals applied (October 13 and 20) in the nursery to several deciduous wood plants (1966)

Plant		'Bartlett' pear		Italian prune		'Chinook' cherry		'Red Rome' apple		'Red Winesap' apple		'Golden Delicious' apple	
		13	20	13	20	13	20	13	20	13	20	13	20
Chemical	Conc (%)[2]												
Potassium iodide (KI)	0 1	100 (5)[3]	100 (4)	100 (5)[3]	100 (3)	100 (5)[3]	100 (3)[3]	0 (5)	0 (4)	50 (4)	10 (3)	10 (4)	0 (3)
	0 15	100 (5)	100 (4)	100 (5)[3]	100 (3)	100 (4)[3]	100 (3)[3]	0 (5)[3]	0 (4)	50 (4)	10 (3)	10 (4)	0 (3)
	0 20	100 (5)[3]	100 (4)[3]	100 (4)[3]	100 (3)	100 (4)[3]	100 (3)[3]	30 (5)	0 (4)[3]	60 (4)	10 (3)	10 (4)	0 (3)
	0 30	100 (4)[3]	100 (4)[3]	100 (4)[3]	100 (3)[3]	100 (3)[3]	100 (3)[3]	70 (5)	0 (4)	60 (4)	10 (3)	10 (4)	0 (3)
KI (0 2%) + b-alanine	1 5	100 (5)[3]	100 (4)[3]	100 (4)[3]	100 (3)	100 (4)[3]	100 (3)[3]	35 (5)	0 (4)	60 (4)	10 (3)	10 (4)	0 (3)
	2 0	100 (4)	100 (4)	100 (4)	100 (3)	100 (3)[3]	100 (3)[3]	35 (5)	0 (4)	60 (4)	10 (3)	25 (4)	0 (3)
KI (0 3%) + b-alanine	1 5	100 (4)	100 (3)	100 (4)[3]	100 (3)	100 (3)[3]	100 (3)[3]	30 (5)[3]	0 (4)	65 (4)	10 (3)	20 (4)	0 (3)
	2 0	100 (4)[3]	100 (3)[3]	100 (4)[3]	100 (3)	100 (3)[3]	100 (3)[3]	30 (5)[3]	30 (4)	75 (4)	10 (3)	20 (4)	0 (3)
b-alanine	1 5	90 (5)	85 (4)	90 (5)	90 (4)	75 (5)[3]	35 (4)[3]	5 (5)	5 (4)	25 (4)	10 (3)	5 (4)	0 (3)
	2 0	100 (5)	85 (4)	90 (5)	90 (4)	75 (5)[3]	35 (4)[3]	5 (5)	5 (4)	25 (4)	10 (3)	5 (4)	0 (3)
Shedaleaf	0 36	100 (5)	100 (4)[3]	100 (5)	95 (4)	100 (4)[3]	100 (3)[3]	75 (4)	60 (4)	80 (4)	30 (3)	85 (4)	20 (3)
	0 48	100 (5)[3]	100 (4)[3]	100 (5)[3]	100 (4)	100 (3)[3]	100 (3)[3]	80 (4)	60 (4)	75 (4)	25 (3)	85 (4)	25 (3)
Biomodine	1 0	100 (4)[3]	100 (4)[3]	100 (5)[3]	100 (3)	100 (4)[3]	100 (3)[3]	40 (5)	0 (4)	95 (4)	15 (3)	55 (4)	0 (3)
	2 0	100 (4)	100 (3)[3]	100 (4)[3]	100 (3)	100 (4)[3]	100 (3)[3]	80 (5)	70 (4)	100 (4)	40 (3)	90 (4)	0 (3)
	3 0	100 (3)[3]	100 (3)[3]	100 (4)[3]	100 (3)	100 (4)[3]	100 (3)[3]	100 (4)[3]	90 (4)[3]	100 (4)	40 (3)	100 (4)	0 (3)
Biomodine (1%) + KI	0 1	100 (3)[3]	100 (3)[3]	100 (4)[3]	100 (3)	100 (4)[3]	100 (3)	70 (5)	0 (4)	95 (4)	5 (3)	40 (4)	0 (3)
	0 15	100 (3)	100 (3)[3]	100 (4)	100 (3)[3]	100 (4)[3]	100 (3)[3]	70 (5)	0 (4)	95 (4)	10 (3)	50 (4)	0 (3)
	0 20	100 (3)[3]	100 (3)[3]	100 (4)	100 (3)	100 (3)[3]	100 (3)[3]	95 (5)	70 (4)[3]	95 (4)	40 (3)	75 (4)	0 (3)
NONE	———	5 (5)		95 (5)		50 (5)		5 (5)		0 (4)		0 (4)	

[1]Figures based on duplicate plots of 3 or more plants each
[2]Concentration calculated on the percentage of formulation used, not active ingredient X-77 used in addition at 1 pint/100 gal
[3]Numbers in parenthesis are the weeks required for the indicated percentage defoliation Plants usually dug by that time.
[4]Terminals damaged at storage time.
[5]Growth after planting not comparable to control

Table 6. (continued)

Plant		'Hi-Early' apple		Japanese greenleaf barberry		P mahaleb sldg		French crab sldg		'Bartlett' pear sldg		P callervana sldg	
Potassium iodide (KI)	0 1	30 (4)	15 (3)	80 (5)	50 (4)	100 (5)	100 (4)	0 (3)	0 (2)	0 (3)	0 (2)	0 (3)	0 (2)
	0 15	40 (4)	15 (3)	80 (5)	50 (4)	100 (5)	100 (4)	0 (3)	0 (2)	0 (3)	0 (2)	0 (3)	0 (2)
	0 20	60 (4)	40 (3)	90 (5)	70 (4) [5]	100 (5)	100 (4)	0 (3)	0 (2)	0 (3)	0 (2)	0 (3)	0 (2)
	0 30	65 (4)	50 (3)	95 (4)	80 (4) [5]	100 (4)	100 (3)	0 (3)	0 (2)	15 (3)	0 (2)	0 (3)	0 (2)
KI (0 2%) + b-alanine	1.5	50 (4)	30 (3)	95 (5)	80 (4)	100 (5)	100 (4)	0 (3)	0 (2)	0 (3)	0 (2)	0 (3)	20 (2)
	2 0	80 (4)	20 (3)	100 (5)	80 (4)	100 (5)	100 (4)	0 (3)	0 (2)	0 (3)	0 (2)	0 (3)	20 (2)
KI (0 3%) + b-alanine	1.5	80 (4)	15 (3)	100 (4)	100 (4)	100 (5)	100 (4)	0 (3)	0 (2) [5]	0 (3)	0 (2)	0 (3)	20 (2)
	2 0	85 (4)	20 (3)	100 (3)	100 (4)	100 (5) [5]	100 (4) [5]	0 (3)	0 (2)	0 (3)	0 (2)	0 (3)	20 (2)
	1 5	15 (4)	10 (3)	65 (5)	65 (4)	35 (5) [5]	55 (4) [5]	0 (3)	0 (2)	0 (3)	0 (2) [5]	0 (3)	0 (2)
	2 0	40 (4)	10 (3)	35 (5)	65 (4)	35 (5)	55 (4) [5]	0 (3)	0 (2)	0 (3)	0 (2)	0 (3)	0 (2) [5]
Shedaleaf	0 36	95 (4)	10 (3)	50 (5)	50 (4) [4]	100 (5) [5]	100 (4)	0 (3)	30 (2)	50 (3)	15 (2)	0 (3)	0 (2)
	0 48	100 (4)	10 (3)	50 (5) [5]	50 (4) [45]	100 (5) [5]	80 (4) [4]	0 (3)	30 (2)	50 (3)	35 (2) [5]	0 (3)	0 (2)
Bromodine	1 0	90 (4)	10 (3)	100 (4) [5]	100 (4) [5]	85 (5) [5]	100 (4)	0 (3)	0 (2)	0 (3)	0 (2)	0 (3)	0 (2)
	2 0	90 (4)	10 (3)	85 (5) [5]	85 (4) [5]	100 (5) [5]	100 (4)	0 (3)	0 (2)	0 (3)	0 (2)	0 (3)	0 (2)
	3 0	95 (4)	15 (3)	50 (5) [5]	80 (4) [45]	75 (5) [5]	100 (4) [4]	50 (3)	0 (2)	65 (3)	0 (2)	45 (3)	0 (2)
Bromodine (1%) + KI	0 1	100 (4)	10 (3)	100 (3)	100 (4)	100 (5)	100 (4)	0 (3)	0 (2)	0 (3)	0 (2)	0 (3)	0 (2)
	0 15	100 (4)	10 (3)	100 (3) [5]	100 (4)	100 (5) [5]	100 (4)	0 (3)	0 (2)	0 (3) [5]	0 (2)	0 (3) [5]	0 (2)
	0 20	100 (4)	10 (3)	100 (3) [5]	100 (4)	100 (5) [5]	100 (4) [5]	25 (3)	0 (2)	0 (3)	0 (2)	0 (3) [5]	0 (2)
NONE	———	0 (4)		50 (5)		5 (5)		0 (3)		0 (3)		0 (3)	

SUMMARY AND CONCLUSIONS

Of the 30 chemicals or chemical combinations used during the 5-year period of this study, DEF (0.25 - 0.75%), Bromodine (1.0 - 2.0%), KI (0.1 - 0.2%), Nacconol NR (0.5 - 1.0%), and KI (0.1%) in combination with Bromodine (1.0%), alanine (1.5 - 2.0%), Nacconol NR (0.5%) or DEF (0.25%) were most successful. These chemicals were all used on a number of plants during at least two years of the study.

The 33 cultivars used varied considerably in their response to defoliants. No satisfactory treatment was found for weigela or for *P. calleryana* seedlings. 'Rome' apples were very difficult to defoliate without injury, probably because they tend to grow late in the season. Apple and pear seedlings (other than *P. calleryana*) varied considerably in ease of defoliation. In general, all plants became more resistant to damage and easier to defoliate as dormancy approached, because growth ceases, tissues harden, and the natural abscission processes begin. Evidence was obtained to show that it would not generally be necessary to wait for complete defoliation prior to digging, but only for adequate loosening of leaves. Subsequent digging and handling prior to storage caused the loss of remaining leaves.

It was evident that two defoliant applications approximately a week apart at low rates would often cause faster defoliation with less injury than a single application of a higher rate. Satisfactory results might be obtained by using a very low rate applied approximately 4 to 5 weeks prior to digging followed by a second application one to two weeks later.

Many factors appeared to influence the response to defoliants, i.e. plant vigor, stage of plant growth, nutrients, moisture, temperature, growing season, location, and individual plant characteristics. It is, therefore, doubtful that a given chemical can be found, except one which is naturally occurring, which will be satisfactory for a large number of plants. If such a chemical can be found, the proper rates will probably vary and the response will be influenced by the above factors. The chemicals mentioned above as being most satisfactory can undoubtedly be safely used on a number of plants, but they cannot be used without regard to the influencing factors just mentioned. Not only is this important, but inadequate care following transplanting may cause undue loss of defoliated plants.

More trials must be made. Undoubtedly, additional promising chemicals will be found. Programs currently underway which are searching for fruit looseners may yield chemicals of value for stimulating leaf abscission (5). More needs to be known of the plant characteristics which influence the penetration and response to defoliants in order to make it

possible to defoliate difficult types. Other approaches to defoliation, such as the use of electrical current or a combination of defoliants and growth regulators might have promise.

LITERATURE CITED

1. Addicott, F T. 1964 Physiology of abscission. *Encyc Plant Physiol.* 15· 1094-1126
2 Blondeau, R 1967 Manager, Product Evaluation, Shell Chemical Co, *Modesto, Calif. Personal correspondence.*
3 Chadwick, L C 1947 Prestorage defoliation of some shrubs and trees *Ohio State Nursery Notes* 16 (8) : 1-5.
4. ----------, and R. Houston 1948 A preliminary report on the pre-storage defoliation of some trees and shrubs *Proc. Amer. Soc Hort. Sci* 51· 659-667.
5 Hartmann H T., M Fadl, and J Whisler 1967 Inducing abscission of olive fruits by spraying with ascorbic acid and iodoacetic acid *Calif Agric.* 21 (7) : 5-7.
6 Kofranek, A. M. and A T Leiser 1957 Defoliation of hydrangea. *Calif Agric* 11 (8) : 12-15
7. Milbrath, J A , E. Hansen, and H Hartman, 1940 The removal of leaves from rose plants at time of digging. *Ore. Agric Exp. Sta. Bul.* 385. 1-11
8 Pridham, A M S. 1952. Preliminary report on defoliation of nursery stock by chemical means *Proc. Amer. Soc Hort Sci* 59: 475-478
9 ----------, 1954 Screening tests of defoliants for nursery stock Paper presented to the Northeast Weed Control Conference
10 ----------. 1956. Defoliants for roses Paper presented to the Weed Soc. of Amer.
11 Roberts, A. N 1950 Pre-storage defoliation of field-grown roses with certain chemical sprays and dusts *Proc Amer. Soc Hort Sci* 56 475-481