Table 1. (Continued)

Prunus salicina 'Ozark Premier'	30.1%	37.5%	24.5%
Prunus salicina 'Santa Rosa'	13.5%	62.6%	52.8%
(Prunus besseni × *P. salicina)* 'Sapa'	39.4%	—	59.7%
Prunus cerasifera "Allred'	13.5%	—	50.0%
(Prunus cerasifera 'Atropurpurea' × *P. salicina)* 'Hollywood'	—	—	77.0%
Prunus cerasifera 'Krauter Vesuvius'	15.4%	49.7%	30.7%
Prunus cerasifera 'Thundercloud'	19.3%	19.7%	29.9%
Average - All Cultivars	24.7%	42.7%	38.5%

[1] Five year average figures of salable trees.
[2] Salable trees produced from grafting.
[3] Live trees produced from grafting. Since herbicide stunted the trees, none will reach salable size the first year.

DEFOLIATION OF NURSERY STOCK FOR EARLY HARVEST[1]

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This paper combines information compiled from the extensive research of Dr. Fenton Larsen of Washington State University, my own recent defoliation study, and a recent survey of nurserymen concerned with the problems and present uses of defoliants.

Late leaf retention has plagued the nursery industry since storage of fall-dug stock began. This problem results in delayed digging and increased labor to hand-strip or "sweat" the leaves off. Heating of foliage in storage causes stem and bud damage and a possible increase in storage molds which can cause losses.

Leaves can be removed by mechanical or chemical means. The most common mechanical methods are hand-stripping and sweating in pits, both of which are expensive. This paper will discuss chemical defoliation.

A good chemical defoliant requires the following: at least 50% defoliation in a short time (2-3 weeks); inexpensive and easy application; and, most important to the nurseryman, not be injurious to treated plants. However, use of defoliants is often limited due to the danger of bud or bark damage and poor growth after transplanting.

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REVIEW OF LITERATURE

Present-day research was initiated by Milbrath *et al.* (10) who constructed chambers in 1937 containing ethylene gas to remove rose leaves. This proved effective within limitations due to the exacting procedures necessary in using ethylene. Later researchers (1,11,12) used Nacconol NR, copper sulfate, and endothal with varying results. Although none of these chemicals is used commercially today, research with them revealed that artificial leaf abscission is affected by concentration and time of application, environmental conditions, cultivar, age, and maturity of the plant. These factors are still of major concern.

In 1963, Dr. Larsen initiated research to find a suitable defoliant. His research through the years has seen the addition and deletion of several "promising" defoliants. The first favorable defoliant was potassium iodide (KI) (2) which is still used on a limited basis by rose growers. Bromodine (a bromine-iodine complex) (4), presently used on cherry and pear, surpassed KI in effectiveness. Larsen recently found that ethephon (Ethrel) and Dupont-WK (a surfactant) provide the best defoliation and least damage (5,6,7,8). Ethephon and D-WK can be used separately with good results or in combination which permits the use of lesser quantities of ethephon. Dupont-WK is slower acting but much safer than ethephon. Several nurserymen prefer it to the combination treatment, ethephon plus D-WK.

Larsen's studies on cycloheximide varied in results (9). Very low concentrations (25-50 ppm) cause rapid and complete defoliation but can be toxic, particularly to pear. Cycloheximide is not now used in commercial nursery practice. More recent research (13, 14) combined ethephon and endothall to provide a synergistic effect. Using the two materials together reduces the concentration of each. These two research efforts prompted our research at Kansas State University, Manhattan.

METHODS AND RESULTS

In October, 1975 we treated 5 species with various combinations of ethephon, endothall, and cycloheximide. Ethephon was applied at 250, 500, 1000, and 1500 ppm; endothall at 0, 250, 500, and 1000 ppm; and cycloheximide at 0, 5, and 10 ppm. The plants treated were 2-year grafts of *Malus* 'Golden Delicious', *Malus* 'Winesap', (*Malus pumila* 'Niedzwetzkyana' × *M. baccata)* 'Hopa' and 1-year seedings of *Malus* and *Pyrus*. Single applications were applied October 1, 1975. Sprays were applied to runoff with hand sprayers. Defoliation and damage was calculated after 2 weeks. The pear and apple seedlings were dug and stored, but the other species remained in the

field. Winter damage for all species was determined in the spring.

Results were encouraging during the fall with excellent defoliation and little terminal damage. The following lower rates were particularly effective: 250 ethephon, 250 endothall, and 10 ppm cycloheximide or 250 ethephon, 500 endothall, and 5 or 10 ppm cycloheximide. Defoliation was not so complete without endothall, even at higher rates of ethephon. Sterrett, *et al.* (13) also observed this synergistic effect between ethephon and endothall. Larsen (7) found that low rates of ethephon were relatively ineffective. Because of this, ethephon and endothall should be combined when lower rates (250 and 500 ppm) are used. These rates, however, are experimental and should not be interpreted as recommendations until further testing can be established.

Damage, as determined in the spring, was heavy. 'Golden Delicious' and 'Winesap' apple and pear seedlings were heavily damaged. The fall of 1975 was unseasonably warm, especially in October, and the 2-year stock in the field broke bud after defoliation. Much less bud-break occurred in 'Hopa' crabapple, which may explain the lesser damage in this species. Several nurserymen also reported that bud-break often occurs unless the nursery plants are dug immediately after defoliation. Additional research is necessary to determine whether the problem is chemical or environmental.

NURSERY SURVEY

The results from the questionnaire sent to nurserymen proved enlightening. Nurserymen experienced similar leaf retention problems with delayed digging. Species most often listed as retaining their leaves are presented in Table 1 and are not restricted to *Malus* and *Prunus*. Nurserymen who responded were interested in a good defoliant, but only about 12% presently are using one successfully. The chemicals most often mentioned were Bromodine, ethephon, and D-WK. The nurseries using chemical defoliants were generally from the Washington State area and had worked with Dr. Larsen. The midwestern and eastern nurseries, with a few exceptions, did not use defoliants.

FUTURE USE

The surveys indicate a ready market for a good chemical defoliant. It is doubtful if a given chemical can be found, except for naturally occurring ones like ABA, which would suffice for a large number of plants. Stone fruits, such as cherries and certain apple cultivars, respond best when defoliants are applied.

Apricot, peach, and pear are easily damaged. A nursery specializing in several large selling items should be able to adapt a safe concentration. Additional research is needed to determine when a plant is dormant to effectively defoliate it. This problem relates to the factors affecting abscission: temperature, humidity, precipitation, moisture, nutrition, species, cultivar, plant age, maturity, timing and concentration of application. Chemical defoliants are similar to herbicides in that mixing and timing of application are very important. Experimental defoliants should be used as cautiously as untested herbicides.

Table 1. List of genera and species having late leaf retention[1]

Acer spp.	*Prunus armeniaca*
Berberis spp.	*Prunus avium*
Betula spp.	*Prunus cerasus*
Castanea mollissima	*Prunus domestica*
Cornus florida	*Prunus mahaleb*
Cotinus spp.	*Prunus persica*
Crataegus spp.	*Pyrus* spp.
Forsythia spp.	*Quercus* spp.
Ligustrum spp.	*Rhamnus cathartica*
Malus spp.	*Rhamnus frangula* 'Columnaris'
Potentilla fruticosa	*Spiraea* spp.
Prunus americana	*Tilia* spp.

[1] This list, obtained from a survey of nurserymen in 1976, includes only those plants listed most often.

LITERATURE CITED

1. Chadwick, L.C. and R. Houston. 1948. A preliminary report on the prestorage defoliation of some trees and shrubs. *Proc. Amer. Soc. Hort. Sci.* 51:659-667.
2. Larsen, F.E. 1965. Potassium iodide induces leaf abscission of deciduous woody plants. *Proc. Amer. Soc. Hort. Sci.* 88:690-697.
3. _____. 1969. Promotion of leaf abscission of deciduous tree fruit nursery stock with abscisic acid. *HortScience* 4(3):216-218.
4. _____. 1970. Prestorage promotion of leaf abscission of deciduous nursery stock with bromodine. *J. Amer. Soc. Hort. Sci.* 95(2):231-233.
5. _____. 1970. Promotion of leaf abscission of deciduous nursery stock with 2-chloroethylphosphonic acid. *J. Amer. Soc. Hort. Sci.* 95(6):662-663.
6. _____. 1972. Surfactant stimulates leaf abscission of tree fruit nursery stock. *HortScience* 7(6):563-564.
7. _____. 1973. Stimulation of leaf abscission of tree fruit nursery stock with ethephon-surfactant mixtures. *J. Amer. Soc. Hort. Sci.* 98(1):34-36.
8. _____. 1973. Successful defoliation of nursery stock with chemicals. *Proc. Inter. Plant Prop. Soc.* 23:62-69.
9. _____. 1974. The effect of cycloheximide and a tridecyl alcohol derivative on leaf abscission of nursery stock. *HortScience* 10(1):61-62.

10. Milbrath, J.A., E. Hansen, and H. Hartman. 1940. The removal of leaves from rose plants at the time of digging. *Ore. Agric. Exp. Sta. Bul.* 385:1-11.

11. Pridham, A.M.S. 1952. Preliminary report on defoliation of nursery stock by chemical means. *Proc. Amer. Soc. Hort. Sci.* 59:475-478.

12. 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.

13. Sterrett, J.P., G.R. Leather and W.E. Tozer. 1973. Defoliation response of woody seedlings to endothall/ethephon. *HortScience* 8(5):387-388.

14. _____, W.D. Foster and D.T. Webb. 1974. Foliar abscission of woody plants with combinations of endothall and ethephon. *Weed Science* 22:608-614.

LILAC PROPAGATION

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We have been propagating lilacs extensively since 1967 and due to the generosity of botanical gardens, arboreta, and park areas supplying propagating material, we now have one of the largest collections in the world and are the official registration authority for the International Lilac Society for lilac cultivars. We are aiming for a complete collection and any new additions would be most welcome. Stocking the collection to where it is today gave me the opportunity to try a great many species and cultivars. I have found lilacs to be consistent performers as far as rooting is concerned, the overall average of rooting during those years being 75-100%.

Timing. I have taken lilac cuttings from early June after flowering until July 26th in quantity, and have found even at this late date 70% rooting was obtained. In most cases we prefer to take our cuttings from the last week in June until the second week in July. Cuttings with mature leaves are much easier to handle. We have had mature-leaved cuttings in plastic bags in cool storage for a week and ended up with 80% rooting.

Media for Rooting. We have used sand, peat, and perlite in various combinations over the years and we find three parts sand to one part peat moss, preferably sphagnum peat, will give us the most consistent results. All cuttings are rooted in boxes for easy handling.

Systems and Method. We use an intermittent mist system with 550-A Florida nozzles overhead in a shaded, double-lined fibreglass greenhouse. The water supply is a well having very