TRANSPLANTING METHOD INFLUENCES SURVIVAL AND GROWTH OF BARE-ROOT CONIFEROUS NURSERY STOCK

by Glen P. Lumis and A. Gail Johnson

Abstract. The survival and subsequent growth of conifers transplanted bare-root using several methods to reduce moisture loss were compared to that of conventional balled and burlapped (B&B) plants. Treating plants with foliar antidesiccant (Wilt-Pruf® NCF) prior to digging combined with storage in Plant Fresh® polyethylene bags was a satisfactory method of bare-root transplanting.

All bare-root transplanted *Juniperus virginiaia* L. 'Grey Rock' (60-70 cm), stored for 5 days, and *Juniperus chinensis* L. 'Keteleeri' (1.5-1.75 m), stored for 16 days, survived and grew as well as the control B&B plants. *Taxus x media* Rehd. 'Andersoni' (50-60 cm) treated with foliage antidesiccant and/or enclosed in poly bags and stored for 5 days had foliar injury similar to B&B plants. Quality was poorer for *Taxus* plants treated with only root antidesiccant. Bare-root transplanting of *Picea abies* Karst. (1.25-1.5m), stored for 14 days, resulted in some foliar injury and reduced shoot growth compared to B&B plants, however, plants treated with foliar antidesiccant and enclosed in poly bags were of acceptable quality. *Thuja occidentalis* L. 'Pyramidalis' (1.0-1.25m) stored for 14 days and transplanted bare-root were of unacceptable quality.

Bare-root transplanting of nursery stock is commonly practiced with deciduous shrubs and small trees while traditionally, conifers have been transplanted with a ball of soil (B&B) in order to retain some soil-root contact and to retard water loss from roots (Pirone 1978). However, B&B moving has several disadvantages. Digging and wrapping the earth ball is labour intensive whether done by hand or machine and is generally done in the busy spring season. High shipping and handling costs are incurred due to the weight of the ball. For example, the average ball weight of a 2m spruce is 200 kg (Annon. 1978). Another disadvantage is the loss of valuable top soil from the production fields. Based on average ball weight it is estimated that 1,400 tonnes of soil/ha are removed with a crop of 2m spruce planted at a density of 7,000 plants/ha. Thus if conifers could be transplanted bare-root, labour, shipping costs and loss of top soil would be reduced.

The roots of bare-root plants are subjected to more rapid drying during digging and planting than plants with a soil ball. Exposure of roots to drying conditions affects survival and long term growth of transplanted trees. Mullin (1974) found that as exposure of white spruce and red pine seedlings increased from one to three hours, survival and growth for as long as five years were reduced. In addition, Mullin (1978) determined that when roots of seedlings were exposed for up to two hours at a relative humidity above 80%, survival was not influenced but at lower relative humidity survival decreased as exposure time increased. Dipping of roots in water after lifting increased survival of white spruce seedlings when roots were exposed to air for one hour or less (Mullin 1974). The use of a mud slurry on roots to reduce desiccation prior to planting is an old forestry practice while dipping of roots in antidesiccant compounds which form a water holding film around roots is reported to have a favourable effect on absorption and water balance of transplants (Kozlowski and Davies 1975).

Foliar antidesiccants reduce moisture stress during transplanting by decreasing the rate of transpiration until root growth and water absorption resume. Davies and Kozlowski (1974) studied the influence of eight film forming products on transpiration and photosynthesis of red pine and white ash seedlings for 32 days. They found the effectiveness differed with antitranspirant material, plant species and environmental conditions. Moisture loss from foliage prior to planting can also be reduced by enclosing plants in moisture-proof containers. Poly-lined Kraft bags and polyethylene bags have been shown to be effective overwinter storage containers for white and black spruce (Mullin and Forcier 1977) and red pine (Bunting 1974).

This study was conducted to assess the feasibility of bare-root transplanting of conifers and to evaluate methods of reducing moisture loss prior to planting.

Methods

In experiments conducted during three years (1975-1977) plants were dug bare-root from a commercial nursery in early May, treated with foliar or root antidesiccants and/or placed in polyethylene bags to reduce moisture loss, stored, then planted in a nursery field of Fox sandy loam. Survival and growth were compared to control plants which were hand dug at the same time using the standard B&B method.

The foliar antidesiccant treatment, a 10% solution of Wilt-Pruf NCF, an organic polymer of B-pinene, manufactured by Nursery Specialty Products Inc., Greenwich, CT, was sprayed at low pressure to cover the foliage and allowed to dry prior to digging. Treatments with Wilt-Pruf NCF were immediately bagged or root-wrapped in poly (Fig. 1). The root antidesiccant treatment, a 1% solution of Agricol which is distributed by Chipman Chemicals Ltd., Hamilton, Ontario, is a water soluble powder of sodium alginate that thickens water allowing it to adhere to the roots and provide a reservoir of moisture. Roots, with soil removed, were dipped into the solution, transported and stored overnight unprotected then the roots were wrapped in poly for the remainder of storage period. Where a polyethylene bag was used as a treatment, the entire plant was enclosed in a Plant Fresh (PF) poly tube and tied at both ends (Fig. 2). Plant Fresh, manufactured by DRG Packaging Ltd., Toronto, Ontario, is a co-extruded polyethylene with black on the inside and grey on the outside.

The planting design for all experiments was a randomized block with conventional nursery field spacings. Plants were watered immediately after planting and irrigated throughout the summer during dry periods. Fertilizer was applied at 100 kgN/ha per season as NH_4NO_3. Success of establishment (survival) and top growth were evaluated for two seasons in each experiment.

Experiment 1. Several methods of reducing moisture loss of bare-root conifers were evaluated with an easy to transplant cultivar — *Junipirus virginiana* 'Grey Rock,' Grey Rock juniper, (60-70 cm) and a more difficult to transplant cultivar — *Taxus media* 'Andersoni,' Anderson yew (50-60 cm). Treatments were: 1) B&B (30 cm ball); 2) PF poly bag (30 cm root dia); 3) PF poly bag (45 cm root dia); 4) Agricol; 5) Wilt-Pruf NCF; 6) combination of 3, 4 and 5. (Junipers did not receive Agricol in treatment 6.) Plants in treatments 3, 4, 5 and 6 were dug with a larger than normal root system (45 cm dia.) since without soil it would increase the shipping weight of the plant only slightly and might benefit plant establishment. After digging and transport plants were stored in a barn for 5 days. Treatments were replicated four times with six (juniper) and four (yew) plants per treatment. Growth of junipers was evaluated by recording the increase in length of two shoots per plant. Shoot injury of yew was evaluated by visual ratings (Fig. 3).

Experiment 2. Based on the findings of the first experiment plant size was increased to 1.5-1.75m using Keteleer juniper (*Juniperus*

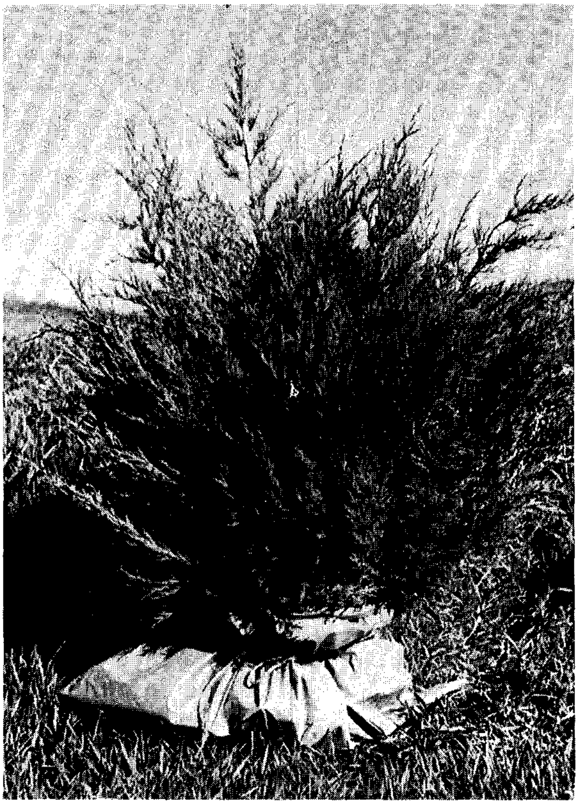

Fig. 1. Bare-root Grey Rock juniper treated with foliar antidesiccant and root-wrapped in PF poly bag.

chinensis 'Keteleeri'), and the number of treatments was reduced to four and storage time increased. Treatments were: 1) B&B; 2) PF poly bag; 3) Wilt-Pruf NCF; 4) Wilt-Pruf NCF + PF poly bag. Roots of bare-root plants averaged 60 cm in dia while B&B plants had a 50 cm earth ball. Roots were moist but not wet when placed in the bags. All plants were stored in a lath house for 16 days. Earth balls were partially heeled-in and watered when required during storage. Wilt-Pruf NCF was re-applied 6 and 14 days after digging to treatment 3 and again at planting to treatments 3 and 4. The weather was mostly cool and wet during storage and during the two weeks following planting. Treatments were replicated four times with three plants per treatment. Growth was recorded in the first season for the terminal and one lateral shoot per plant while in the second season the terminal and three lateral shoots per plant were measured.

Experiment 3. Since junipers are relatively easy to transplant, we chose *Picea abies*, Norway spruce (1.25-1.5 m), and *Thuja occidentalis* 'Pyramidalis,' Pyramid white cedar (1.0-1.25 m), because they might be influenced more by root drying and long-term storage. Treatments were: 1) B&B; 2) Wilt-Pruf NCF; 3) Wilt-Pruf NCF + PF poly bag. Roots with soil removed were sprayed with water prior to wrapping or bagging. Plants were stored in a lath house for 14 days with balled plants heeled-in and watered. Wilt-Pruf NCF was applied to treatment 2 after one week and to treatments 2 and 3 at planting. The weather during storage was generally sunny and warm (about 20°C at mid-day), then hot (above 28°C) and dry for 10 days following planting. Treatments were replicated five times with one plant per treatment in each replicate. Growth was evaluated by measuring three lateral shoots per plant on white cedar and the terminal as well as all laterals of the second whorl from the top on Norway spruce.

Results

Juniper. Plants in all bare-root treatments sur-

Fig. 2. Bare-root Keteleer juniper enclosed in PF poly bags.

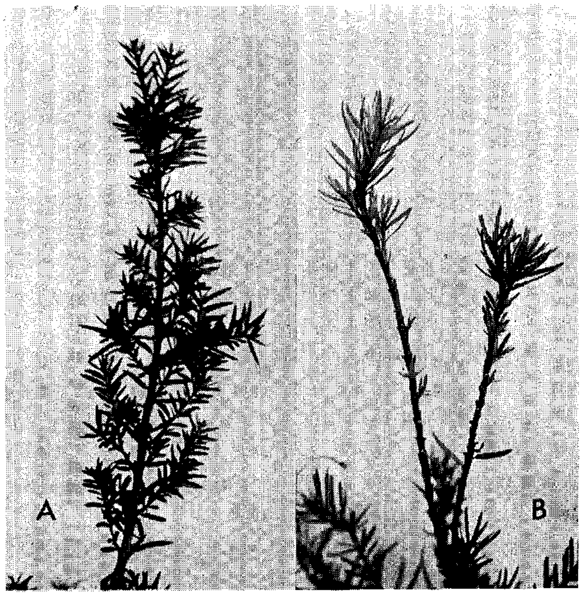

Fig. 3. Injury ratings of yew: A, rating 1 (no injury); B, rating 2 (some needle loss).

vived and grew as well or better than B&B plants in both trials. Grey Rock juniper transplanted bare-root, treated with Wilt-Pruf NCF and enclosed in a PF poly bag during the five days of storage grew more than other treatments in the first season but in the second season growth was similar in all treatments (Table 1). No foliage injury was observed on any plants. These junipers were relatively small (60-70 cm) and storage time was short thus it is not surprising that the plants responded well to bare-root transplanting. The larger initial root system (45 cm) resulted in almost twice as much shoot growth as the 30 cm root in the first season but this difference was not statistically significant.

Table 1. Influence of transplanting methods on shoot growth of Grey Rock juniper and on foliar injury of Anderson yew.

	Juniper		Yew	
	Shoot growth (cm)			
Treatment	*1st year*	*2nd year*	*Injury rating*[1]	*% with injury*
B&B	1.4 b[3]	20.8	1.8 b	63
PF poly bag (30 cm root)	1.0 b	19.6	1.8 b	78
PF poly bag (45 cm root)	1.9 b	20.4	1.7 b	69
Agricol	0.9 b	21.6	2.5 a	88
Wilt-Pruf NCF	1.5 b	16.3	1.5 b	50
Wilt-Pruf NC + PF poly bag[2]	3.4 a	23.3	1.6 b	56
		NS[4]		

1. Ratings: 1 = no injury; 2 = partial needle loss, no twig dieback; 3 = extensive needle loss and twig diebadk and 4 = dead
2. Yew also treated with Agricol
3. Mean separation within columns by Duncan's Multiple Range Test, 5% level
4. NS = F-test not significant at 5% level

All Keteleer juniper in experiment 2 were of acceptable quality with growth after two years similar in all treatments (Table 2). Plants in the PF poly bag treatment had the least shoot growth in the first year but the differences were not statistically significant. Some drying and loss of older foliage was observed during the first season. Control plants and those in the PF poly bag treatment had the most needle drop while plants treated wtih Wilt-Pruf NCF + PF poly bag had the least needle drop.

Yew. All transplanting treatments, including B&B, resulted in some foliar injury. Injury ratings based on needle loss and shoot die back indicated that plants treated with Agricol alone were of significantly poorer quality (Table 1) and had the greatest percentage of plants showing some injury. Wilt-Pruf NCF alone or combined with PF poly bag + Agricol resulted in the best quality plants. The size of the initial root system had little influence on the amount of foliar injury or plant survival.

Table 2. Influence of transplanting methods on shoot growth (cm) of Keteleer juniper.

	Terminal shoot		Lateral shoots[1]	
Treatment	*1st year*	*2nd year*	*1st year*	*2nd year*
B&B	12.2	36.1	3.8	22.5
PF poly bag	9.9	35.0	2.6	22.3
Wilt-Pruf NCF	11.1	33.7	3.8	19.1
Wilt-Pruf NCF + PF poly bag	12.0	35.1	3.7	20.6
	NS[2]	NS	NS	NS

1. Data based on one shoot per plant in 1st year and on three shoots per plant in 2nd year
2. NS = F-test not significant at 5% level

Spruce. Transplanting of spruce was more successful B&B than bare-root. The B&B plants had significantly more lateral shoot growth than bare-root treatments in both the first and second season after transplanting, however, differences in terminal growth were less pronounced (Table 3). Plant quality was also influenced by transplanting method. During the two weeks of storage the shoots of B&B plants grew 2-3 cm. Plants in the PF poly bags also grew during storage but due to the lack of light inside the bag the growth was etiolated (Fig. 4). Normal green color was restored on most of these shoots by mid-June with only slight browning of some needles, but the needles were shorter (8.3 mm versus 10.8 mm) and more adpressed to the twig than on B&B plants throughout the first growing season. Those plants treated with Wilt-Pruf NCF + PF poly bag were of acceptable but poorer quality than B&B plants.

Spruce treated with Wilt-Pruf NCF (only roots wrapped) made no shoot growth during storage. All of these plants survived transplanting but were of poor quality and did not produce normal growth in the first season with needle length extremely short and average lateral shoot length of only 1.3 cm compared to 14.7 cm for B&B plants (Table 3). In the second season the quality of bare-root transplanted spruce improved although shoot growth was still less than on B&B trees. Needle length was similar in all treatments. Bare-root plants which were treated with Wilt-Pruf NCF (only roots wrapped) were very small and compact due to short shoots of the previous year (Fig. 5).

White cedar. Pyramid white cedar did not respond well to bare-root transplanting. Foliage of bare-root plants treated with Wilt-Pruf NCF (only roots wrapped) was very brown and desiccated a few days after transplanting and all plants in this treatment were dead by mid-summer. Foliage of plants treated with Wilt-Pruf NCF + PF poly bags was similar to B&B plants at planting but after 4 days the bare-root plants showed some browning of foliage. Throughout the first season bare-root plants were of poor quality with much leaf drop of older foliage. While overall size of B&B plants appeared to equal bare-root plants the growth of measured shoots was less (2.2 cm versus 4.0 cm). In the second season the bare-root plants again made greater shoot growth than B&B plants. All B&B plants were heavy with fruit thus making less vegetative growth while only one bare-root plant had much fruit. White cedar transplanted bare-root were more open in the centre due to extensive leaf drop in the previous season (Fig. 6).

Discussion

The Agricol root dip treatment provided no foliar protection against water loss and the small amount of moisture held around the roots by Agricol provided little water for uptake to counteract the loss through transpiration, resulting in greater foliar injury of yew than with other treatments. Foliar injury of yew treated with Agricol combined with Wilt-Pruf NCF + PF poly bag was similar to that of plants treated with either Wilt-Pruf of poly bag alone indicating no adverse

Fig. 4. Norway spruce after storage for two weeks in a PF poly bag showing etiolated shoot tips.

Fig. 5. Norway spruce 15 months after transplanting. Treatments left to right: B&B; Wilt-Pruf NCF; Wilt-Pruf NCF + PF poly bag.

Table 3. Influence of transplanting methods on shoot growth (cm) of Norway spruce.

	Terminal shoot		*Lateral shoots*[1]	
Treatment	*1st year*	*2nd year*	*1st year*	*2nd year*
B&B	23.9 a[2]	27.8 a	14.7 a	16.0 a
Wilt-Pruf NCF	4.9 b	28.6 a	1.3 c	12.2 c
Wilt-Pruf NCF + PF poly bag	18.0 a	16.6 a	11.5 b	14.4 b

1. Average growth of shoots in second whorl from top
2. Mean separation within columns by Duncan's Multiple Range Test, 5% level

effect of Agricol on the plants. Agricol was not used in further trials due to the inconvenience in handling and lack of positive benefits. Mullin (1977) found no advantage in dipping roots of Jack pine or black spruce seedlings in Agricol prior to storage. The benefit of Agricol might be realized to a greater extent in situations where roots could not be wrapped immediately after lifting or during periods of very low relative humidity since the exposed solution remained moist during transport and overnight storage of yew and Grey Rock juniper plants.

Fig. 6. Pyramid white cedar 15 months after transplanting. Left: Wilt-Pruf NCF + PF poly bag; Right: B&B (foliage more dense).

The effectiveness of foliar antidesiccants as a transplanting treatment depends on the plant species treated, the durability of material under environmental stresses and its influence on the physiology of the plant. Little information is available in the effect of Wilt-Pruf NCF on plant processes but a similar pinolene based compound, Vapor Gard was found to reduce transpiration and photosynthesis of apple trees for 7 days under conditions of low soil moisture with no influence on shoot growth after 21 days (Weller and Ferree, 1978). However, the response of conifers to Wilt-Pruf NCF may be different. Albrigo (1977) found that a 2% solution of Wilt-Pruf NCF formed a less persistent film than Vapor Gard on leaves of orange trees. Davies and Kozlowski (1974) reported a difference in species response to several compounds which reduced transpiration from white ash leaves for a shorter time than from red pine needles due to more complete coverage of the needles and greater persistence of the film in stomatal pores of red pine. Photosynthesis was reduced in both species. However, extreme durability of the film is not always desirable since a reduction in photosynthesis could result in reduced plant growth. Alternatively, the increased water potential created by reduced transpiration may temporarily increase cell expansion and growth in spite of reduced photosynthesis (Davenport et al. 1972). Davies and Kozlowski (1974) suggest that persistent leaf coatings may be phytotoxic due to accumulation of toxic metabolites within the leaf but in our trials plants treated with Wilt-Pruf NCF showed no foliar injury. Kozlowski and Davies (1975) also suggest that partial coverage of foliage may sufficiently reduce transpiration to maintain a favourable water balance while allowing adequate CO_2 exchange to continue. In the high stress situation of bare-root transplanting any adverse effects of antitranspirants on growth may be far outweighed by the beneficial effects on survival and establishment of the plant.

In our experiments, it was not possible to assess whether Wilt-Pruf NCF had any direct effect on shoot growth enhancement or retardation. In general, growth of plants treated with Wilt-Pruf NCF was similar to that of B&B plants in the first year and also in the second year when the result of reduced photosynthesis might be exhibited. Although spruce treated with Wilt-Pruf NCF alone were smaller than B&B plants they were also smaller than plants treated with Wilt-Pruf NCF + PF poly bag. Thus, other factors such as drying of the foliage or roots during storage, must have influenced establishment rather than a direct detrimental effect of Wilt-Pruf on shoot growth. Under the extremely dry conditions during storage the exposed film may have broken down more readily than inside the bag or during previous experiments when weather was more favourable.

After planting the foliage of both bare-root treatments of spruce would be under similar stress. The necessity of repeated applications of foliar antidesiccants during storage and at planting depends on environmental conditions such as wind, temperature and humidity which may hasten film breakdown.

Poly bags reduce moisture loss from the foliage during storage but after planting there is no protection against transpiration water loss whereas with the combination treatment of Wilt-Pruf NCF + PF poly bag there is continued foliar protection after planting. Growth of Grey Rock and Keteleer juniper stored in bags alone was less in the first year than on plants in the combined Wilt-Pruf NCF + PF poly bag treatment. The combined treatment also resulted in more shoot growth on Grey Rock juniper, spruce and white cedar plants than Wilt-Pruf NCF alone indicating that the bag complements the effectiveness of the foliar antidesiccant.

One disadvantage of the PF poly bag was the etiolation of new shoots on spruce during storage. Perhaps earlier lifting or storage at a cooler temperature and/or for a shorter time will be required for this and similar species stored in bags. Labelling of plants enclosed in dark poly bags will be more critical for the nurseryman than when tops are exposed and disposal of bags at the planting site may also be a problem for the landscape contractor. Clear poly bags have not been used for field planting since exposure to sunlight for long periods during transplanting could result in plant injury due to high temperatures within the bag. Lumis (unpublished data) found that the temperature in clear poly bags containing nursery stock averaged 10°C higher than the temperature in PF poly bags (41°C vs 31°C) over a three hour period on a sunny day in an unshaded location. Temperatures inside clear bags were also higher during cloudy weather.

The average weight of B&B plants was 7 to 20 times heavier than similar bare-root plants, depending on species (Table 4). The improved ease of handling and reduced shipping weights of bare-root plants are obvious advantages to both the nursery grower and landscape contractor. Extended storage time of bare-root plants would probably present more problems than for B&B plants unless plants are dug when dormant and stored in controlled environments. Bare-root stock may also require more care after planting such as irrigation and plants must be staked since there is no soil ball to anchor the plant.

The very dry weather conditions during and after planting the spruce and white cedar probably had a great influence on plant establishment. Although these two species were not grown in other years for comparison, it is likely that survival and growth would be better under conditions of lower temperature and higher relative humidity during transplanting. The response of yew to bare-root transplanting was encouraging in this study but the storage time was quite short. With a longer storage period the stress would probably be greater on bare-root plants than on B&B plants and more differences might be observed.

Table 4. Comparison of the average shipping weights (kg) of B & B and bare-root plants used in transplanting trials.

Species	*B & B*	*Bare-root*
Anderson yew	22.9	1.5
Grey Rock juniper	30.9	1.6
Norway spruce	38.0	5.6
Pyramid white cedar	36.1	3.1

Summary

Bare-root transplanting of Grey Rock and Keteleer juniper was successful while all species tested showed promise of being suitable under some circumstances. The root system must not be allowed to dry at any time from lifting until planting and moisture loss through transpiration from the foliage must be reduced. Foliar application of Wilt-Pruf NCF combined with enclosing the entire plant in PF poly bag was the most satisfactory treatment for bare-root plants.

Acknowledgment. The authors thank DRG Packaging Ltd., Chipman Chemicals Ltd. and Nursery Specialty Products Inc. for materials, Sheridan Nurseries Ltd. for plants, the Ontario Ministry of Agriculture and Food for financial support and finally Mr. F. Leech for technical assistance.

Literature Cited

Albrigo, L.G. 1977. *Comparison of some antitranspirants on orange trees and fruit.* J. Amer. Soc. Hort. Sci. 102:270-273.

Anonymous. Guide specifications for nursery stock 1978. Canadian Nursery Trades Association.

Bunting, W.R. 1974. Cold storage tests. Ontario Ministry of Natural Resources, Nursery Notes No. 35.

Davenport, D.C., M.A. Fisher, and R.M. Hagan 1972. *Some counteractive effects of antitranspirants.* Plant Physio. 49:722-724.

Davies,W.J. and T.T. Kozlowski 1974. *Short- and long-term effects of antitranspirants on water relations and photosynthesis of woody plants.* J. Amer. Soc. Hort. Sci. 99:297-304.

Kozlowski, T.T. and J.W. Davies 1975 *Control of water balance in transplanted trees.* J. Arboric. 1:1-10.

Mullin, R.E. 1974. Effects of root exposure on establishment and growth of outplanted trees. International Symposium Ecology and Physiology of Root Growth. Berlin, 1974.

Mullin, R.E. 1971. *Root exposure, root dipping and extended spring planting of white pine seedlings.* For. Chron. 54:84-87.

Mullin, R.E., and J.R. Forcier 1977. A test of Kraft bags, celery crates and "Plant Fresh" bags for overwinter storge. Ontario Ministry of Natural Resources, Nursery Notes No. 51.

Mullin, R.E. and R.E. Hutchison 1977. Agricol, clay and water dipping tests with Jack pine and black spruce nursery stock. Ontario Ministry of Natural Resources, Forest Research Note. No. 10.

Pirone, P.O. 1978. Tree maintenance. Oxford University Press, New York, 587 p.

Weller, S.C. and D.C. Ferree 1978. *Effect of pinolene-base anti-transpirant on fruit growth, net photosynthesis, transpiration, and shoot growth of 'Golden Delicious' apple trees.* J. Amer. Soc. Hort. Sci. 103:17-19.

Associate Professor and Research Technician,
Department of Horticultural Science,
University of Guelph,
Guelph, Ontario, Canada

ABSTRACTS

Anonymous. 1980. **New Dursban labels clear way for native elm bark beetle control.** Weeds Trees & Turf 19(3): 92-94.

New labels for Dursban are providing a backup defense against Dutch elm disease in states where the native elm bark beetle is the primary vector. The Environmental Protection Agency has approved a national label for Dursban 2E and a Local Needs Registration for Dursban 4E in Minnesota where research on native elm bark beetle management has been centered. Two formulations of the chlorpyrifos-based insecticide are registered for use in Minnesota — Dursban 2E and Dursban 4E. Application rate is .5 percent active ingredient with water, sprayed to wet (not run-off) the basal 2 to 2½ meters (6-8 feet) of standing healthy elm trees. The Minnesota 24c label must be in the possession of the user at time of application. Fall treatment is preferred because native bark beetles can introduce the fungus directly into healthy trees as they make their overwintering tunnels.

Gilbertson, Henry. 1980. **The challenges and limitations of tree pest management today.** Weeds Trees & Turf 19(3): 18, 20, 22.

There are basic difficulties in controlling tree pests. These are in addition to those problems involving particular trees or pests. We often receive calls after the damage is quite extensive. Tall trees are a problem. Even with ideal conditions, it is difficult to thoroughly spray trees that are 85 to 90 feet in height. The fact that most of our insecticides have short residual and are used on insects that have extended egg-hatch periods or that may continue to reinfest a tree over a long period of time, makes control difficult. Two other problems that need further publicity are the effect of temperature on insect control, and the effect of water pH used with the pesticide, which can reduce its chemical activity. The insects discussed represent a few of those prevalent problems to urban trees and, in some cases, problems for arborists to control.