EFFECT OF TRUNK INJECTION OF UNICONAZOLE ON THE GROWTH OF NORWAY MAPLE AND GREEN ASH OVER FOUR YEARS

by Geoffrey P. Arron, Lori A. Bremner and W. Barclay Cormack[1]

Abstract. In a 4-year field study, Norway maple (*Acer platanoides*) and green ash (*Fraxinus pennsylvanica*) trees (average dbh at time of treatment: 22.4 and 13.4 cm, respectively) were trimmed to a uniform height and trunk injected with the growth regulator uniconazole in the spring of 1988. The rates of application were 0.1 g and 0.2 g a.i. per cm trunk diameter for the maple and ash, respectively. The growth of the trees, in terms of increase in height and in trunk diameter, was determined each fall until 1991. Growth of the ash was significantly inhibited for the four years (43% in height and 33% in diameter). Increase in trunk diameter of maple was significantly inhibited (43%), but there was no significant inhibition of increase in height. Some injection holes in the maple bled after application, but none bled in the ash. No bark damage was seen in the ash, but in the maple some bark cracks were observed.

While there have been many reports of the effectiveness of growth regulators such as paclobutrazol, flurprimidol and uniconazole in retarding growth in woody and non-woody species (for reviews see 7,8,9,18) there have been few quantitative studies on the use of such products applied by trunk injection to control the growth of trees under or close to electric distribution lines. In a study conducted for the Empire State Electric Energy Research Corporation (ESEERCO) the literature was examined for reports associated, directly or indirectly, with trees and overhead utility lines, and/or the application of growth regulators to woody species (11,12). Of 549 publications identified only 72 were related to utilities and/or application of tree growth regulators. In another part of the ESEERCO study, it was found that of 160 utilities in North America which responded to a questionaire, 81 were using tree growth regulators on an operational or trial basis (10). Only 19 of 81 had performed any statistical analysis on the results from such applications, and while 23 utilities had performed a cost-benefit analysis, only one had demonstrated that the applications were cost effective. Thus while it appears that the use of growth regulators by electrical utilities has been quite extensive, there are few accounts in the literature of the efficacy and cost effectiveness of such applications.

In the studies performed by or for utilities (and other studies with woody species), the efficacy of growth regulators applied to seedlings, saplings, and trees has been determined using a variety of measures, such as increases in height, trunk diameter, the length of (some) terminal or lateral sprouts, and the weight of material removed at trimming (1,2 13,16,19,23,25). Sprout (or shoot) length has been the most popular measure. In the crown of a mature red maple (*Acer rubrum*) Wilson has estimated there are 20,000 short- and 1,000 long-shoots (24). In silver maple (*Acer saccharinum*) sprouts increase in length by a few cm to a meter or more per year (2). In growth regulator efficacy studies workers have measured the increase in length of sprouts selected at random from this large population (e.g., the selection of 20 sprouts per tree at mid-crown (25)). Some of the reports from utilities quote values for inhibition of growth, but provide no information on how growth was measured (15,21). Increase in height of a tree is easier to measure than sprout growth but it is a conservative measure in that the rapid growth of one or more sprouts at the top of the crown, sometimes called water sprouts (13), can

1. Superintendent Forester, Retail Delivery Systems, Ontario Hydro Regions Branch, 5775 Yonge St., North York, Ontario, Canada, M2M 4J7.

give a large increase in height, even though all other sprouts have grown little.

While there have been reports of the effectiveness of uniconazole in inhibiting the growth of several woody species (3,19), there have been few reports of long-term experiments examining the effects of trunk injection of uniconazole, and other growth regulators such as paclobutrazol and flurprimidol, on woody species (7). Translocation experiments with uniconazole have shown that after injection most of the product remains around the injection point, with little translocated up the stem and into the foliage (3,19,20). Metabolism of uniconazole appears slow in both the foliage and the stem near the injection point (3,4,19,20), suggesting that as long as product is translocated to the growing points in sufficient quantities, then inhibition of growth will be seen over the long-term. In the present study, the effect of trunk injection of uniconazole on the growth of Norway maple (*Acer platanoides*) and green ash (*Fraxinus pennsylvanica*), as measured by increase in height or trunk diameter, was investigated over four growing seasons.

Materials and Methods

Norway maple and green ash trees, growing in Toronto and London, Ontario respectively, were trimmed flat across the top to a height of 6.1 m and 6.7 m, respectively, in June, 1988. Trunk diameters (dbh) had been measured and the trees were ranked by diameter, with odd trees being injected and even trees not, or vice versa, to ensure the treated and control groups contained trees of similar trunk diameter. Six maple were injected with uniconazole (0.1 g active ingredient (a.i.) per cm trunk diameter) 5 days after trimming and twelve ash (0.2 g a.i. per cm) 21 days after trimming. Stock solutions were 20 g/L for the ash and 10 g/L for the maple. The latter was prepared by diluting the 20 g/L solution 1:1 vol:vol with isopropyl alcohol. Injection holes were made at approximately 15 cm intervals around the trunk about 15 to 20 cm above soil level. Holes, typically 5 to 6 cm in depth, were made with a Makita drill with a 5.5 mm (7/32 in) brad point wood bit, at a slight downward angle, about 5° to 10° from the horizontal, and at a 30° to 45° angle to the plane of the trunk to intercept the outer sapwood. Injections were performed with T.I.S. Stallion 75 injectors using an initial pressure of 621 KPa. After injection the holes were sealed with a silicone sealant to prevent pathogen entry. Control trees were trimmed and not injected. Such controls were chosen because, for a utility, it has to be demonstrated that the complete treatment (trimming plus drilling and pressure injection of uniconazole in a carrier) offers advantages over the present vegetation control method (trimming alone). Tree height and trunk diameter were measured each fall from 1988 to 1991, and each spring and fall the injection holes were checked for bleeding and the bark above and around the holes examined for splits and cracks. In the fall of 1991 it was discovered that three of the ash trees (two treated and one control) had been removed by a local forestry crew and thus no 1991 height or trunk diameter data could be collected. In addition the top of one tree was lost in an ice storm and so the height could not be determined but the trunk diameter could.

Results and Discussion

Injection times for the maple were fast (mean of 8.4 minutes per hole for a total of 29 holes, range of 3.4 to 19.4 minutes) and the ash slow (mean 25.8 minutes per hole for 32 holes, range 2.8 to 71.8 minutes). Watson (22) reported average injection times of 7.3 minutes for Norway maple and 28.2 minutes for white ash. In a recent study conducted at Newmarket, Ontario, injection times for green ash were reported to be short (about 5 minutes), although these trees were injected in the fall (17). Injections performed from July through November were reported to be quicker than the rest of the year for a variety of species (22). In addition, injection times were shorter in diffuse porous species than ring porous species. Norway maple and green ash are diffuse and ring porous species, respectively.

Seven of the 29 holes in the maple bled at some time during 1988. In June 1989, 14 holes were bleeding, and by the spring of 1990 only two. Bleeding in Norway maple has been reported previously (6). No bark splits were observed in the maple, although the bark around two holes was cracked - with one crack the result of the bark being lifted at injection. Bark splitting was found above 16% of injection holes in Norway maple in an earlier study (15). No holes in the green ash bled and no bark splits or cracks were observed in the present study.

The effects of uniconazole on tree growth are presented in Table 1. For both tree species in each of the 1989, 1990 and 1991 growing seasons there was a significant reduction in the increase in trunk diameter as a result of uniconazole application. For the four growing seasons combined (1988-1991) treatment with uniconazole resulted in a reduction of the increase in trunk diameter for both species. No significant effect on trunk diameter was seen in 1988. The trees were injected in late June 1988 when growth had already started. Hence values for increase in trunk diameter and height for untreated trees are lower for 1988 than subsequent years (Table 1). The data for increase in trunk diameter also were calculated as percent inhibition (Table 2). Levels of inhibition were consistent for the 1989 through 1991 growing seasons for both tree species, with no indication of a decline of inhibition. This suggests a longevity of effect which may carry over into 1992 and beyond. Lack of inhibition in the first year of treatment has been reported before (3) and is probably the result of application of the growth regulator after the growth flush has started and the delay in the product getting from the point of application to the growing points (3).

The data for increase in tree height were less consistent. In the green ash there was little inhibition in 1988 and then about 50% inhibition in both 1989 and 1990, apparently declining to 24% in 1991 (Table 2). The height data for Norway maple were inconsistent however, with no significant inhibition over the four growing seasons (Tables 1 and 2). The number of Norway maple trees used in the experiment was small (12 - all that were available) and a lack of consistency of response between trees led to this result. One treated tree grew 3.5 m during the experiment,

Table 1. Increase in height and trunk diameter of green ash and Norway maple trees from 1988 to 1991 following trimming and trunk injection with uniconazole.

			Increase in height (m)+					Increase in trunk diameter (cm)+				
Species	Treatment	Number of trees	1988	1989	1990	1991	Total 1988-91	1988	1989	1990	1991	Total 1988-91
Green ash	Control	12*	0.12 ±0.08a	0.80 ±0.41a	0.65 ±0.34a	0.55 ±0.34a	2.11 1.05a	0.2 ±0.2a	0.7 ±0.3a	0.7 ±0.3a	0.6 ±0.3a	2.1 ±0.6a
Green ash	Uniconazole	12**	0.10 ±0.05a	0.34 ±0.16b	0.29 ±0.21b	0.42 ±0.21a	1.20 ±0.51b	0.2 ±0.2a	0.5 ±0.2b	0.4 ±0.2b	0.4 ±0.2b	1.4 ±0.4b
Norway maple	Control	6	0.58 ±0.63a	0.63 ±0.44a	0.28 ±0.19a	0.28 ±0.25a	1.77 ±0.51a	0.4 ±0.2a	1.2 ±0.3a	1.1 ±0.3a	1.2 ±0.3a	3.9 ±1.1a
Norway maple	Uniconazole	6	0.34 ±0.13a	0.72 ±0.62a	0.24 ±0.34a	0.11 ±0.16a	1.40 ±1.10a	0.2 ±0.1a	0.7 ±0.2b	0.7 ±0.2b	0.7 ±0.3b	2.2 ±0.7b

± Values are mean ± standard deviation. If the mean values for the control and treated trees of a species are followed by different letters they are significantly different as determined by a t test.

* 1991 height data was obtained for 10 trees (not 12) and trunk diameter data for 11 trees (for explanation see Materials and Methods). As a consequence the mean value for growth for the period 1988-1991 was also calculated for 10 and 11 trees (increase in height and trunk diameter, respectively).

** 1991 data for height and trunk diameter were obtained from 10 trees, not 12 (see materials & methods for explanation). For growth over the period 1988-1991 mean values were calculated for 10 trees.

Table 2. Inhibition of growth from 1988 to 1991 in Norway maple and green ash trees following trimming and trunk injection with the growth regulator uniconazole.

		Inhibition of growth (%)+									
		Increase in height					Increase in trunk diameter				
Site	Species	1988	1989	1990	1991	Total 1988-91	1988	1989	1990	1991	Total 1988-91
London	Green Ash	19	57a	56a	24	43a	19	32a	41a	38a	33a
Toronto	Norway Maple	41	+12	14	61	21	42	43a	42a	43a	43a

+ Inhibition calculated from the mean values given in Table 1. A positive value (eg +12) represents an apparent stimulation of growth. Percentages followed by the letter a indicate a significant inhibition as determined by a t test (Table 1).

while all other treated trees grew 1.5 m or less. As discussed above, increase in tree height is a conservative measure of growth. However it may still be a better measure than sprout length given the range in length of the sprout population.

There have been previous reports of the inhibition of growth in woody species following the trunk injection of uniconazole (3,19) but such studies were short-term. In determining the effectiveness of growth regulators from a utility perspective it might be useful to examine the trimming exercise itself, by measuring the time taken or cost to trim treated trees, the frequency of trimming, and the weight of material removed at trimming. The latter has been determined for fruit trees by two groups (16,23). In addition it has been reported that after the inhibitory effects of paclobutrazol, also a triazole, diminish there is accelerated sprout growth (5). The consequences of this to long-term tree health are unknown. Because of the problems associated with trunk injection, namely the bark splitting and cambial damage reported by some applicators (14), the efficacy of growth regulators implanted in capsule form should be investigated. Such a method would avoid the use of large volumes of carrier, such as methanol or isopropyl alcohol, applied under pressure.

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Associate Research Scientist and Research Technician, respectively
Biological Research Section
Ontario Hydro Research Division
800 Kipling Avenue
Toronto, Ontario M8Z 5S4, Canada

Résumé. Pour les besoins d'une étude de quatre ans, des érables de Norvège et des frênes de Pennsylvanie (22.4 et 13.4 cm, respectivement, en diamètre moyen au moment du traitement) furent taillés à une hauteur uniforme et furent injectés avec un régulateur de croissance, l'uniconizole, au printemps de 1988. Les taux d'application pour les deux espèces furent, respectivement, de 0.1 et 0.2 g par cm de diamètre. La hauteur et le diamètre du tronc furent pris à tous les automnes jusqu'en 1991. La croissance du frêne fut significativement inhibée au cours de ces quatre années (43% en hauteur et 33% en diamètre). La croissance en diamètre du tronc de l'erable fut significativement inhibée (43%), tandis qu'il y eut aucune inhibition significative pour la croissance en hauteur. Quelques trous d'injection coulèrent chez l'érable après l'application, mais aucun chez le frêne. Aucun dommage à l'écorce fut observé chez le frêne alors qu'il y eut quelques fendillements d'écorce chez l'érable.

Zusammenfassung. Bei einer Studie über vier Jahre wurden Spitz-Ahorn- und Rot-Eschen-Bäume auf eine einheitliche Höhe beschnitten (durchschnittlicher Brusthöhendurchmesser zur zeit der Behandlung: 22,4 und 13,4 cm) und im Stamm mit dem Wachstumsregulator 'Uniconizole' im Frühjahr 1988 injiziert. Je Zentimeter Durchmesser wurden 0,1 g und 0,2 g für jeweils beide Arten appliziert. Baumhöhe und Stammdurchmesser wurden in jedem Herbst bis 1991 bestimmt. Das Wachstum der Esche war über die vier Jahre deutlich gehemmt (43% bei der Baumhöhe und 33% beim Durchmesser). Die Zunahme des Stammdurchmessers beim Ahorn war deutlich reduziert (43%), aber es gab keine bedeutende Hemmung eines Höhenzuwachses. Einige der Injektionslöcher am Ahorn bluteten nach der Anwendung, an der Esche dagegen in keinem Fall. Rindenbeschädigungen wurden an der Esche nicht beobachtet, jedoch einige Rindenrisse beim Ahorn.