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RAY MALEIKE: How old were the trees that the cuttings came from?

DOUGLAS CHAPMAN: They were mature and cuttings were taken throughout the plant.

RALPH SHUGERT: Would you comment on your accelerated growth technique and the use of supplementary light?

DOUGLAS CHAPMAN: Harold Davidson and I believe that the production techniques could be significantly different. There is no reason why we could not root the cuttings, develop a good root system, put them in cold storage, and bring them back into a greenhouse in March. By doing this you would be back into an acceptable daylength and good light quality. We have looked at leaving the rooted cuttings under lights; however, we did not get any response until fertility levels were acceptable.

BILL CUNNINGHAM: You mentioned disinfecting the cuttings. What did you use for this purpose?

DOUGLAS CHAPMAN: We use 10% Clorox and it did reduce the amount of rot we encountered.

ELWIN ORTON: I would just like to comment on the study that he alluded to that I did earlier. Working with single node cuttings we obtained 96% rooting in 3 weeks with cuttings taken in July. In preliminary work with cuttings taken in August and September we got 90% rooting.

CUTTINGS FROM HERBICIDE-TREATED NURSERY STOCK — WHAT CAN WE EXPECT?

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Abstract. Fourteen herbicides were tested on cultivars of *Taxus*, *Juniperus*, *Rhododendron*, *Leucothoe* and *Pieris* from 1970 to 1979. Mature tip cuttings were harvested from 2 container and 6 field experiments following herbicide applications. None of 11 soil-applied (preemergence) herbicides and only one of the 3 postemergence herbicides caused significant reductions in rooting of cuttings. Some herbicides were applied at 2 to 4 times normal rates and reapplied 4 to 5 times in containers, or 2 to 3 times in the field before cuttings were taken. The only significant effects on rooting of cuttings from treated plants were obtained when glyphosate was sprayed over *Taxus* in

May, August or November, and cuttings were taken in December, January, or March. Glyphosate caused less foliar injury to *Juniperus horizontalis* 'Plumosa' than to *Taxus cuspidata* during any season of application and did not affect rooting of cuttings from the treated junipers.

About a decade ago we became aware of the need to evaluate effects of herbicides on rooting as another criterion for herbicide safety in nursery stock. From then on, whenever possible, we have rooted cuttings from our herbicide treated plots and evaluated the results. In 1972, we reported experimental results obtained with 16 herbicides (1,2). We found that most herbicides either caused no significant effects on rooting of cuttings or did so only when applied at excessive dosages which often caused plant injury. McGuire and Pearson (7) applied simazine (Princep) and diphenamid (Dymid and Enide) on container-grown ornamentals. Simazine, but not diphenamid, injured *Ilex* and *Rhododendron* cultivars and reduced the rooting quality of softwood cuttings taken 30 days after treatment. 'San Jose' juniper was less affected. Fretz (6) also applied several herbicides at normal and excessive dosages on container-grown azaleas and evaluated the rooting response of softwood cuttings. Diphenamid (Dymid), trifluralin (Treflan), and chlorpropham (Chloro IPC) caused no effects on rooting, but 3 to 4 times normal dosages of EPTC (Eptam), simazine, and dichlobenil (Casoron) reduced rooting response.

This report summarizes the results of 8 field and container experiments conducted since 1972 as they relate to herbicidal effects on rooting potential.

MATERIALS AND METHODS

Herbicide evaluation experiments were conducted at the Valley Laboratory of the Connecticut Agricultural Experiment Station and in commercial nurseries. Uniform samples of cuttings were taken from replicated plots of herbicide treated plants and rooted in the greenhouse. Cuttings from randomized field plots also were randomized and replicated in the rooting benches. The techniques and conditions varied greatly from one test to another, but were uniform within each experiment.

When the cuttings were lifted, rooting of each was evaluated on a scale of 1 to 6 as follows:

1 = dead
2 = callused, but no roots
3 = poor (one or more very small roots)
4 = fair (roots developed on part of cutting)
5 = good (roots on all but one side of cutting)
6 = excellent (roots all around cutting)

Percentage rooting was based on the percentage of cuttings

Table 1. Herbicides tested for effects on rooting of cuttings from treated plants.

Common name	Trade name and formulations	Chemical name
alachlor	Lasso 10G, 15G, 4 EC	2-chloro-2′,6′diethyl-N-(methoxymethyl)acetanilide
asulam	Asulox, liquid	methyl sulfanilylcarbamate
bentazon	Basagran, liquid	3-isopropyl-1H-2,1,3-benzothiadiazin-4(3H)-one 2,2-dioxide
bifenox	Mowdown 80W	methyl 5-(2,4-dichlorophenoxy)-2-nitrobenzoate
glyphosate	Roundup, liquid	N-(phosphonomethyl)glycine
methazole	Probe WP and 5G	2-(3,4-dichlorophenyl)-4-methyl-1,2,4-oxadiazolidine-3,5-dione
napropamide	Devrinol 10G and 50W	2-(α-naphthoxy)-N,N-diethylpropionamide
oryzalin	Surflan 75W and 5G	3,5-dinitro-N^4,N^4-dipropylsulfanilamide
oxadiazon	Ronstar 75W, 2G, 4G	2-tert-butyl-4-(2,4-dichloro-5-isopropoxyphenyl)-Δ^2-1,3,4-oxadiazolin-5-one
oxyfluorfen	Goal 2G	2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene
perfluidone	Destun 50W	1,1,1-trifluoro-N-[2-methyl-4-(phenylsulfonyl)phenyl]methane-sulfonamide
pronamide	Kerb 50W	3,5-dichloro(N-1,1-dimethyl-2-propynyl)benzamide
simazine	Princep 80W and 4G	2-chloro-4,6-bis(ethylamino)-s-triazine
trifluralin	Treflan 5G	α,α,α-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine

ranking fair (Class 4) or better. Cuttings judged fair or better were considered fit for transplanting with an excellent chance for survival. Rooting scores were calculated by summarizing these ranks and dividing this by the total number of cuttings within each group. Rooting scores represent the average root quality of a group of cuttings. For analysis of variance, rooting percentages usually were transferred into angles and rooting scores were analyzed directly.

The herbicides evaluated for potential effects on rooting are given in Table 1. All dosages of herbicides are given in pounds of active ingredient (ai) or acid equivalent (ae) per acre (lb/A).

RESULTS

Container-grown plants. Data presented in Tables 2 and 3 are from an experiment in which 7 herbicides are applied 4 or 5 times over 2 seasons. Mature tip cuttings were taken 2 to 4 months after the final applications in July and August 1978 and rooted under mist.

Table 2. Percentage reduction in weeding time and fresh weights of *Juniperus horizontalis* 'Plumosa Compacta', and rooting of cuttings from plants receiving 4 or 5 applications of herbicides in containers over a 2-year period.[1]

Herbicide	Rate (ai, lb/A)	Percent reduction in weeding 2nd year[2] July	Aug	Juniper top weights (grams)	Rooting Percentage	Rooting score
untreated controls,	0	0	0	63	92	5.1
periodically weeded	0	0	0	108	90	4.6
napropamide 10G	4	55	41	132	92	4.8
	16	47	20	87	82	4.7
oryzalin 5G	4	99	80	156	62	4.1
	16	100	97	166	50	3.4
oxadiazon 2G	4	94	80	142	70	4.3
	16	99	91	124	75	4.2
alachlor	4	36	70	104	92	4.6
	16	78	96	127	75	4.1
oxyfluorfen 2G	2	95	97	170	78	4.3
	8	99	97	170	78	4.3
trifluralin 5G	4	78	64	111	87	5.0
	16	95	82	168	72	4.3
methazole	4	94	74	139	67	3.8
	8	99	82	172	77	4.8
oxadiazon+ oryzalin	2+2	92	80	144	85	4.7
alachlor +	4+0.8	78	91	156	75	4.2
simazine	8+1.6	99	99	120	72	4.2
L.S.D. p = .05				47	N.S.	N.S.
p .01				62	N.S.	N.S.

N.S. difference not significantly different at p = .05.

[1] Alachlor and alachlor plus simazine were applied in June, Aug. and Oct. 1977, and May and July 1978. The other herbicides were applied in June and Sept. 1977, and May and Aug. 1978. Cuttings were taken Nov. 2, 1978 and rooted under mist.

[2] Weeding of the untreated controls cost an estimated $1407 per acre for the 2-month period.

Table 3. Rooting percentage of cuttings taken following four applications of herbicides in containers over a 2-year period.[1]

Herbicide	Rate (ai, lb/A)	*Leucothoe fontanesiana*	*Rhododendron* 'Chinoides'	*Pieris japonica*	*Rhododendron* 'Louise'
controls, weeded		75	100	84	22
periodically		87	100	90	41
napropamide 10G	4	95	88	83	30
	16	82[2]	100	79	50
oryzalin	4	82[2]	92	80	38
	16	76[2]	92	82[2]	22[2]
oxadiazon 2G	4	82	100	78	42
	16	72[2]	100	77[2]	21
		N.S.	N.S.	N.S.	N.S.

N.S. difference not statistically significant at p = .05

[1] The herbicides were applied in June and Sept. 1977, and May and August, 1978. Cuttings were taken Oct. 3, 1978 and rooted under mist.

[2] Plants showing foliar injury or reductions in vigor from the herbicide treatment.

The time required to weed the untreated containers during July and August of the second season was 0.71 minutes per gallon container. Based on 40,000 gallon containers per acre and a labor cost of $3.00/hr this translates to weeding costs of $1,407 per acre for that 2 month period. As seen in Table 2, most herbicides at the low rate (normal rate) markedly reduced weeding times and therefore weeding costs. Weeding times were higher than expected with napropamide because of the predominance of creeping woodsorrel (*Oxalis corniculata*) that is resistant to napropamide. The higher weeding times for alachlor relative to the other herbicides are due in part because alachlor was last applies in May, whereas the other herbicides were applied in June. Reapplication of alachlor in July following weeding gave improved weed control in August.

The rooting results with cuttings from *Juniperus horizontalis* 'Plumosa Compacta' (Table 2) show apparent reductions in rooting from oryzalin at normal rates (X) and 4 times normal (4X) rates and trends in reduced rooting with other herbicides. Because of variability, however, the differences in rooting were not statistically significant at the 5% probability level. However, most treatments sharply reduced weed populations and many produced significantly more growth than the untreated controls. Increased vigor may have been a factor in apparent reduced rooting percentages of cuttings.

The rooting percentages of *Leucothoe*, *Rhododendron* 'Chinoides', *Pieris japonica* and *Rhododendron* 'Louise' following 4 applications of napropamide, oryzalin, and oxadiazon in this experiment are given in Table 3. None of these herbicides, even at 4X dosages, significantly affected rooting of cuttings taken 6 weeks after the final application. This was true even though some treatments reduced the vigor of either foliage or roots, or both.

In a second two-year container trial conducted at another commercial nursery during 1977 and 1978, neither alachlor nor alachlor plus simazine at extreme dosages significantly affected the rooting of cu and sand, for example.

Table 4. *Rooting of cuttings of Rhododendron catawbiense* 'Nova Zembla' following 5 applications of alachlor alone or with simazine in 1-gallon containers.[1]

Herbicide	Rate (ai, lb/A)	Rooting Percentage	Rooting score
untreated		63	4.0
alachlor 15G	4	74	4.5
	8	68	4.3
	16	57	4.1
alachlor 15G+	4+0.8	57	4.1
simazine	8+1.6	61	4.2
	16+3.2	69	4.6
		N.S.	N.S.

N.S. difference not statistically significant at p = .05.
[1] The rhododendrons were planted on June 9, 1977 and treated June 14, 1977, Aug. 1977, Oct. 1977, May 1978, and July 1978. Cuttings were taken Oct. 4, 1978, rooted under mist, and evaluated Feb. 28, 1979.

Field-grown Taxus and junipers. *Taxus* and junipers are widely grown in wholesale nursery production in Connecticut. Almost annually since 1970 an experiment has been started in which newly planted *T. cuspidata* and Juniperus horizontalis 'Plumosa' (Andorra juniper) were treated in May or June with experimental and standard herbicides and retreated a year later. The soil is a sandy loam with an organic matter content of 2 to 3%. Cuttings were taken in December or January following the second herbicide application, as in normal nursery practice. The cuttings were rooted in sand with bottom heat and intermittent mist and evaluated about 3 months after sticking. As shown in Table 5, a number of herbicides, even at 2X and 4X rates failed significantly to affect rooting of cuttings from the treated plants. Perfluidone injured both the *Taxus* and junipers, but did not affect rooting of cuttings. Bentazon caused slight injury on *Taxus* at 2 lb/A, but also had no effect on rooting of cuttings.

In a trial started in May, 1977, napropamide was applied before planting and oryzalin plus simazine after planting six *Taxus* cultivars. All treatments were reapplied on the soil surface the following spring. Cuttings were taken in January, 1978. None of the treatments significantly affected rooting of the cuttings (Table 6).

Table 5. Herbicide treatments (lb, ai/A) causing no significant effects on rooting of cuttings from *Taxus cuspidata* or *Juniperus horizontalis* 'Plumosa' as compared with untreated periodically weeded controls.

Years in which cuttings were taken		
1973[1]	1976[2]	1978[3]
napropamide WP or G3 or 6	perfluidone WP 3 or 6[4,5]	napropamide G or WP 4 or 8
pronamide WP 2 or 4	bifenox WP 3 or 6	oxyfluorfen 2G, 4 or 8
methazole WP or G3 or 6	oxadiazon WP 2 or 4	oryzalin WP, G or AS 2,4 or 8
alachlor G, 4 or 8		alachlor G, 4, 8 or 16
alachlor G + simazine G 4 to 6 + 1.5 to 3	alachlor EC + simazine WP, 5 or 10 + 1.5	oxadiazon G, 4 or 8
		bentazon 1 or 2[5,6]
simazine G, 3	simazine WP 1.5	oryzalin WP + simazine WP 2 + 1.5
trifluralin G 2	oryzalin WP 2 or 4	
trifluralin G + simazine G 2 + 1.5	oryzalin WP + simazine WP 1.5 + 2	
	asulam 3 or 6	
	asulam + oxadiazon WP 3 or 6 + 2 or 4	

[1] The herbicides were applied May 8, 1970, May 12, 1971, and May 13, 1972. Cuttings were taken in January, 1973.
[2] The herbicides were applied June 11, 1975 and May 26, 1976. Cuttings were taken in December 1976.
[3] The herbicides except bentazon were applied May 18, 1977 and May 19, 1978. Cuttings were taken in December 1978. Bentazon was applied in June and August of 1977 and 1978.
[4] Treatments that injured *Taxus*.
[5] Treatments that injured juniper.
[6] Bentazon severely injured juniper and no juniper cuttings were taken.

Table 6. Effects of napropamide and simazine plus oryzalin in the field on rooting percentage of cuttings from treated *Taxus* cultivars.[1]

Herbicide	Rate (ai, lb/A)	*T. cuspidata*	*T.* 'Brownii'	*T.* 'densiformis'	*T.* 'Hicksii'	*T.* 'Hatfieldii'	*T.* 'Greenwave'
untreated		100	96	79	87	96	79
simazine + oryzalin	1.5+2	95	100	71	92	100	96
napropamide	4	100	96	79	67	87	96
	8	100	100	75	96	100	83
		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

N.S. difference not statistically significant at p = .05
[1] Treatments were applied in May, 1977 and again in April, 1978. Cuttings were taken in January, 1979 and rooted in sand under mist.

The effects of asulam and glyphosate sprays applied at 4 different times of the year over established plants of *T. cuspidata* and *Juniperus horizontalis* 'Plumosa' were evaluated in 1973 and 1974 (Table 7). Asulam at 3 or 6 lb/A at any date of application caused no plant injury and had no effect on rooting of cuttings.

Glyphosate caused only slight injury to the junipers during active growth, but did not affect rooting of cuttings. However, glyphosate killed shoot tips of *Taxus*, especially at 1.5 lb/A during May or August (3). As shown in Table 7, August and November applications on *Taxus* markedly reduced the rooting percentages of cuttings taken in December or January. These results were confirmed in another experiment with glyphosate in a commercial nursery during 1975 (Table 8). Glyphosate at 0.75 lb/A (1 qt Roundup per acre) in August 1975, killed established annual grasses with little or no observable injury to *T. media* 'Densiformis' or 'Greenwave'. However, cuttings taken from treated *T.* 'Greenwave' the following March failed to root as well as cuttings from adjacent untreated plants. Cuttings from treated *T. media* 'Densiformis' were slightly affected.

Table 7. Effects of asulam and glyphosate applied at different times on the rooting percentage of cuttings of *Taxus cuspidata* and *Juniperus horizontalis* 'Plumosa'.[1]

Herbicide	Rate, lb/A[2]	Time of application	Taxus 1973	Taxus 1974	Juniper 1973	Juniper 1974
untreated controls	0	—	96	99	82	96
asulam	3	Apr. 18-19	88	95	90	98
	6		98	98	81	95
	3	May 30-31	92	93	73	95
	6		96	97	85	100
	3	Aug. 8-9	92	100	88	98
	6		92	100	75	97
	3	Nov. 5-7	92	100	63	100
	6		96	98	83	95
glyphosate	0.5	Apr. 18-19	92	100	83	98
	1.5		98	98	60	100
	0.5	May 30-31	100	100	85	98
	1.5		96	80	81	85
	0.5	Aug. 8-9	90	98	77	95
	1.5		56	85	79	97
	0.5	Nov. 5-7	79	97	85	93
	1.5		4	20	79	98
L.S.D. p = .05			18	12	N.S.	N.S.
p = .01			24	16		

N.S. differences not statistically significant at p = .05.

[1] The herbicides were sprayed over the plants in 50 gal solution/A once each year at the specified time. Cuttings were taken from the plants in Dec or Jan, rooted in sand under mist and evaluated in the spring. Each figure represents an average of 60 cuttings.

[2] lb/A active ingredient for asulam and lb/A acid equivalent for glyphosate.

Table 8. Effect of August application of glyphosate on rooting of *Taxus* cuttings.[1]

Treatment	*Taxus media* 'Densiformis' Percent rooted	*Taxus media* 'Densiformis' Rooting score	*Taxus* 'Greenwave' Percent rooted	*Taxus* 'Greenwave' Rooting score
untreated	96	4.9	72	3.9
glyphosate 0.75 lb/A[2]	88	4.9	22	3.2

[1] glyphosate was sprayed over the Taxus in Aug. 1975. Cuttings were taken on March 10, 1976, rooted in sand, and evaluated July 20, 1976. Each figure represents an average of 100 cuttings sampled from 4 different areas of the treated plots.

[2] acid equivalent.

DISCUSSION

Of the 14 herbicides applied alone or in combination in 8 field and container experiments, only one caused significant reductions in rooting of cuttings. The herbicide was glyphosate, a systemic growth regulator type herbicide with apparently long residual effects in woody plants. Glyphosate is registered for preplant and directed applications in nursery plantings, but not for broadcast spraying over nursery plants such as was done in our experiments. Since glyphosate is adsorbed and inactivated on the soil it is unlikely that directed sprays of glyphosate would affect rooting of cuttings from treated plants.

A number of the herbicides that were included in these experiments are not yet registered for use in ornamental plantings. These included asulam, bentazon, bifenox, methazole, oxyfluorfen, and perfluidone. Asulam has been effective in postemergence control of annual grasses and certain broadleafed weeds in narrow-leafed evergreens, whereas bentazon has given late season postemergence control of yellow nutsedge in *Taxus* (5). Oxyfluorfen and bifenox are preemergence herbicides that may eventually become available for use in ornamental plantings. None of these herbicides appear to affect rooting of cuttings from *Taxus* or juniper in the field.

Herbicides that have become registered for nursery use and hence available to growers since our earlier reports (1,2) include oxadiazon (Ronstar), napropamide (Devrinol), oryzalin (Surflan), and alachlor (Lasso). There has been no indication from these or previous studies that normal rates of oxadiazon, alachlor or oryzalin affect rooting of cuttings from treated plants. Further, despite their wide use by nurserymen, we have not heard of any problems in rooting of cuttings that might be related to use of these herbicides.

Napropamide has become available to nurserymen more recently than the other materials. In 1972, we reported reducing rooting of softwood cuttings of *Rhododendron* 'Daviesi' and 'PJM', but not *Rhododendron* 'Tunis' or 'Purple Gem' (2). One grower also reported to us that napropamide appeared to have reduced rooting of cuttings from treated *Taxus*. In the work reported here, where all of the cuttings were from mature shoots, we saw no evidence of rooting reduction from napropamide on 6 *Taxus* cultivars in the field and 5 species including 2 *Rhododendron* cultivars in containers.

The herbicide simazine has been used by nurserymen for almost 2 decades. Previous reports (2,7) have indicated that simazine can affect rooting potential of cuttings from certain plants, but in those instances simazine was tested on plants of marginal tolerance and under conditions for which no label registration has been granted. Simazine currently is registered for use on certain established ornamentals grown in the field, but not in containers. Nevertheless, most of our results with low rates of simazine (1 lb/A) in containers have shown no significant effects on rooting response. Stock plants grown in containers are more vulnerable to adverse effects of herbicides because a greater number of applications are required and with leachable soil mixes and heavy irrigation, herbicides can move into root zones.

CONCLUSIONS

These studies and those reported previously permit several conclusions about the effects of soil-applied herbicides on rooting of cuttings from treated plants. No herbicide has consistently reduced rooting of cuttings and most observed effects have occurred under one or more of the following conditions: (1) at higher than normal herbicide dosages which often caused plant injury, (2) on plants with marginal tolerance to the herbicide, (3) at short time intervals following herbicide application, or (4) on softwood cuttings rather than mature cuttings. Precise herbicide applications at dosages and on plants specified on the herbicide label are not likely to cause problems in rooting of cuttings. However, it is wise to use all new herbicides on a trial basis, leaving comparable untreated plants, so that tolerance and rooting response can be observed under the growers' conditions. This is particularly true in container plant culture. We must continue to evaluate potential effects of herbicides on rooting of cuttings from stock plants. At this time, however, the bulk of the evidence suggests that properly applied, herbicides do not post a threat to plant propagation.

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