ing effects and the less frequent applications make this herbicide a more economical material for our operation.

Some research has been done on using dilute amounts of Roundup over the tops of established plants to clean up weeds. Self (1,2) and Whitcomb (3) have had good results with this process. We have tried to duplicate some of their work but, to date, we have not been successful. We have either killed the plants or not obtained weed control. I am sure that when rates and usage are refined, Roundup will be used quite widely in the nursery industry.

Roundup, as we see it, is one of the best new herbicides to come our way in a long time. It is a material that I am sure you will find to your liking.

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AFTER TRIALS WITH HERBICIDES, A DECISION IS MADE

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Abstract. Nine herbicides were evaluated for their effectiveness in reducing weed growth in twenty cultivars of containerized nursery stock. Alachlor at 4 lb ai/A and 6 lb ai/A and 4 lb ai/A showed generally the least amount of phytotoxicity but also demonstrated the poorest weed control of all nine herbicides evaluated. Profluralin at 6 lb ai/A and 9 lb ai/A gave fair weed control and only slight damage to the plant materials. Tests with napropamide at 6 lb ai/A and 8 lb ai/A indicated fair to poor weed control followed by moderate damage. The combination of alachlor at 4 lb ai/A and 6 lb ai/A with trifluralin at 4 lb ai/A and 6 lb ai/A, respectively, demonstrated moderately effective weed control with slight to moderate plant damage. Oxadiazon at 2 lb ai/A and 4 lb ai/A in granular, wettable powder, and emulsifiable concentrate forms showed excellent weed control, but also moderate to excessive damage to nursery stock. Alachlor at 4 lb ai/A and 6 lb ai/A combined with simazine at 1 lb ai/A and 1.5 lb ai/A, respectively, gave poor weed control with only one application during the growing season. However, with two applications, weed control was excellent, but damage was excessive.

INTRODUCTION

With the rising costs of producing quality container nursery stock, and the increasingly competitive market, it became apparent that there was a need to decrease the production cost per unit. Until three years ago all of the container nursery stock at Greenleaf Nursery was entirely hand-weeded. It is reported that over 600 man-hours are required to hand-weed one acre of containerized nursery stock. This figure correlates to our approximate cost of $1000/A. Fretz (3) demonstrated the need for growing nearly weed-free nursery stock for quality. His research proved that the dry weight of Japanese holly (*Ilex crenata*, (Thumb.) cv. *convexa* Makino) decreased as much as 60% in a 2.4 liter container when the quantity of weeds increased. Poor quality results from slow crop growth due to competition for nutrients and moisture between the nursery stock and the weeds.

Unfortunately, there is limited information concerning herbicide usage on container nursery stock. This primarily results from lack of interest of the chemical companies due to the small nursery market for them, compared to the risks involved with labelling a product for nursery use. Since few of the available herbicides on the current market give the necessary weed control over the broad-spectrum of plant material existing in nurseries, increased interest has encouraged research both on an individual basis and with the chemical companies in this area.

For the past three years Greenleaf has conducted research into the possibilities of incorporating herbicides into the weed control program, thus reducing the production cost per unit. This year with the herbicidal research program, we have evaluated nine herbicides at various rates as listed in Table 1. This year closer attention was paid to the phytotoxic effect which may have resulted from the rates necessary to obtain the best possible weed control.

Table 1. Herbicides Evaluated in 1976.

Trade Name	Common Name	Manufacturer	Application Rates ai/A
Devrinol 10 G	Napropamide	Stauffer Chemical Co.	6-8 lbs
Lasso 15 G	Alachlor	Monsanto Co.	4-6 lbs
Princep 4 G	Simazine	CIBA-GEIGY	1-1 1/2 lbs
Ronstar 2 G	Oxadiazon	Chipman Division of Rhodia Inc.	2-4 lbs
Ronstar 25% EC	Oxadiazon	Chipman Division of Rhodia Inc.	2-4 lbs
Ronstar 75% WP	Oxadiazon	Chipman Division of Rhodia Inc.	2-4 lbs
Surflan 75% WP	Oryzalin	Elanco Products Co.	2-4 lbs
Treflan 5 G	Trifluralin	Elanco Products Co.	4-6 lbs
Tolban 2 G	Profluralin	CIBA-GEIGY	6-9 lbs

MATERIALS AND METHODS

The research for this year was established on July 1, 1976, with the twenty cultivars of plants listed in Table 2. For each

cultivar 190 plants were selected for uniformity of growth from our standard beds of 120 × 6'. These liners were planted in 2.4 liter polyethylene containers and allowed to establish for a minimum of eight weeks. Each of the herbicides, and the combinations of alachlor and simazine, and alachlor and trifluralin, as listed in Table 1, were evaluated using ten plants × 2 rates × twenty cultivars, bringing each test block to a total of 400 plants per herbicide.

Table 2. Plant Material Utilized in 1976 Herbicide Research.

1. *Azalea indica* 'Formosa'	11. *Ilex cornuta* 'Burfordii'
2. *Buxus microphylla japonica*	12. *Ilex crenata* 'Helleri'
3. *Elaeagnus macrophylla* 'Ebbengi'	13. *Nerium oleander*
4. *Euonymus japonica* 'Aureo-variegata'	14. Photinia fraseri
5. *Euonymus japonica* 'Grandiflora'	15. *Pinus caribaea*
6. *Gardenia jasmininoides* 'Mystery'	16. *Pittosporum tobira* 'Variegata'
7. *Lonicera* spp.	17. *Pyracaakoidzumii* 'Victory'
8. *Juniperus horizontalis* 'Wiltonii'	18. *Viburnum suspensum*
9. *Lagerstroemia indica*	19. *Washingtonia robusta*
10. *Ligustrum Japonicum* 'Texanum'	20. *Yucca aloifolia*

The plants were grown in a highly organic mix consisting predominantly of pine bark. The granular herbicides were applied with a Gandy herbicide applicator which was carefully calibrated before each application of the herbicides. The wettable powder formulations and emulsifiable concentrates were applied with a one gallon CO_2 constant-pressure sprayer calbrated at 40 psi to deliver at 6-1/2' band with #8003 Tee Jets at a volume of 30 gal per acre. The treatments were completed on July 2, 1976, and the containers irrigated with 1/4" of water with overhead sprinklers to incorporate the herbicide. Each container was fertilized prior to the herbicide treatment with one teaspoon of 18-9-13 osmocote. Throughout the experiment overhead liquid fertilizer was used to maintain proper quality of plant material.

Initial weed counts and phytotoxicity symptoms were evaluated 28 days after the herbicide application. Actual weed counts were taken, with those results listed in Table 3. The predominant weeds encountered were: bittercress (*Cardamine hirsuta* L.), weeping woodsorrel (*Oxalis corniculata* L, barnyard grass (*Echinochloa crusgalli* Beauv.), and sowthistle (*Sonchus oleraceus* L.). Each cultivar was given a phytotoxicity rating. The rating system was 0 to 10.0, with 0 representing no physical damage and 10.0 representing death of every plant within the cultivar tested.

Eleven weeks after the initial treatment, an application of the individual herbicides was applied again to half of each of the 20 cultivars, using the same experimental rates as the initial application. The same precautions were utilized in calibrating the Gandy applicator and with the constant pressure CO_2

sprayer. Again, after the treatments, the herbicides were incorporated into the soil with a 1/4 inch of water.

Weed counts were taken and phytotoxicity symptoms were rated 3 weeks after the herbicide application. Those results are listed in Table 4. The results of weed counts and phytotoxicity ratings of the plant material not treated the second time are listed in Tables 5 and 6. Similarly, the same rating system: 0 to 10.0 was employed.

RESULTS AND DISCUSSION

Alachlor (LASSO®) was evaluated at 4 and 6 lb ai/A. These evaluations were made at the lower and higher rates with either one or two applications during the growing season. With no appreciable difference in damage with both rates, alachlor is still the standard for other chemicals to be measured against. Alachlor also gave fair weed control when applied at 6 lb ai/A only once without any adverse effects. Since alachlor has a short duration of weed control, it must be applied at 6-8 week intervals for acceptable weed control. However, since it is readily leachable, the phytotoxic symptoms may increase as shown in this research.

Oryzalin (SURFLAN®) at 4 and 8 lb ai/A provided excellent weed control in the previous year's research followed by severe phytotoxic effects. However, this year at 2 lb ai/A and 4 lb ai/A, oryzalin produced little or no phytotoxic effects but exhibited the poorest weed control of all nine herbicides evaluated. This data concurs with that of Whitcomb & Butler (7), which states that oryzalin appears unsuitable for container use due to rapid leachng and high potential for plant damage.

Profluralin (TOLBAN®) at 6 and 9 lb ai/A gave fair weed control with only slight damage to the plant material. Research has shown profluralin to be effective against bittercress in weed control; however, this was not the case in this year's research. Profluralin reduced the amount of weeping woodsorrel by as much as 90% when compared to the control. With bittercress there was no significant reduction in weed counts with profluralin. Profluralin may still show promise in future evaluations for good weed control without plant damage if used, possibly, at a higher rate of application.

Napropamide (DEVRINOL®) evaluated at 6 and 8 lb ai/A showed fair to poor weed control with moderate damage. Research with napropamide at higher rates of application to obtain acceptable weed control would possibly result in excessive damage to the plant material. However, it should be noted that napropamide does effectively control bittercress. Napropamide seems to be too specific for the broad spectrum of weeds that

we encounter. Therefore, napropamide appears not suited for our particular micro-environment of growing conditions.

Alachlor (LASSO®) applied at 4 lb ai/A and 6 lb ai/A combined with trifluralin (TREFLAN®) at 4 lb ai/A and 6 lb at ai/A, respectively, showed moderate weed control and phytotoxic effects. Fretz (4) reported that trifluralin at 4 lb ai/A combined with alachlor at 1.5 ai/A gave excellent control of grasses but poor control of broadleaf weeds. Since most the weeds we encounter are broadleaf, this combination is not acceptable for our use.

The oxidiazon (RONSTAR®) products all provided excellent weed control, yet were highest in phytotoxicity. Initially, all three products demonstrated similar phytotoxic effects. With the second application the granular form proved to be less phytotoxic than the others. The emulsifiable concentrate was the most damaging. This could be expected with the petroleum distillate carrier in the EC form. Even with spot burn from the granular form on *Yucca aloifoilia* L., the overall effects were not as severe as with the wettable powder and emulsifiable concentrate forms. For weed control, the EC proved to be more effective than the WP and G forms when applied twice during the course of the experiment, but the G and WP forms still gave excellent weed control. However, with only one application, the EC fell behind the other oxadiazon formulations in weed control.

Despite this, oxadiazon seems very promising for weed control in container grown nursery stock. However, oxadiazon has an initial stunting effect on plant material which may or may not grow out of it. Perhaps reevaluation at lower rates or frequencies of application would suffice without sacrificing weed control. Skimina (6) recommended that oxadiazon be applied at 2.25 lb ai/A. With this year's research, this rate falls within those that we applied resulting in excellent weed control but also moderate to heavy damage. This was especialy true with *Ilex cornuta* var. *Burfordii* and *Yucca aloifolia*. All of our research has shown oxadiazon to result in excessive damage, ranging from severe stunting to 50% death of the experimental plants to these two cultivars. Since Greenleaf uses a large percentage of very porous organic material in its soil mix, this would possibly explain the severe phytotoxic effects due to the slight leaching of the chemical in the media.

Alachlor (LASSO®) at 4 lb ai/A and 6 lb ai/A combined with simazine (PRINCEP®) at 1 lb ai/A and 1.5 lb ai/A, respectively, gave poor weed control with only one application during the growing season. With two applications, alachlor and simazine gave excellent weed control but likewise resulted in excessive damage to the plant material. Dean *et al.* (2) have re-

Table 3. Effects of nine herbicides (two applications) on various weed species of 20 container-grown broadleaf ornamental shrubs.

Weed counts[1]	Rates of Appl. (lb ai/A)	*Cardamine hirsuta* L. (bittercress)	*Oxalis corniculata* L. (weeping woodsorrel)	*Sonchus oleraceus* L. (sow thistle)	*Euphorbia nutans* Lag. (spotted spurge)	*Echinochloa crus-galli* Beauv. (barnyard grass)
control	—	124	54	2	18	1
alachlor 15% G	2	3	20		2	
	4	2	3			
oxadiazon 2% G	2	1	4		3	
	4	1	3			
oxadiazon 75% WP	2	1	2			
	4	1	1			
oxadiazon 25% EC	2					
	4		2			
oryzalin 75% WP	2	31	34	5	1	
	4	12	15			
profluralin 2% G	6	60	1			
	0	31				
napropamide 10% G	6	34	4			
	8	6	31		1	
alachlor 15% G + trifluralin 5% G	4/4	17	7			
	6/6	4	5			
alachlor 15% G + simazine 4% G	4/1	2	17			
	6/1.5		6	1		

[1] Weed Counts were made 10-11-76, 93 days after the herbicide application.

Table 4. Cumulative phytotoxicity ratings with two herbicide applications.

Herbicide	Rate of Application (lb ai/A) Low Rate	High Rate	Phytoxicity Ratings Low Rate	High Rate
control	—	—	0.0	0.0
alachlor 15% G	2	4	0.30	1.05
oxadiazon 2% G	2	4	3.15	3.65
oxadiazon 75% WP	2	4	3.18	4.47
oxadiazon 25% EC	2	4	4.25	4.68
oryzalin 75% WP	2	4	0.86	1.20
profluralin 2% G	6	9	1.00	1 50
napropamide 10% G	6	8	1.40	1.40
alachlor 15% G + trifluralin 5% G	4/4	6/6	1.71	1.95
alachlor 15% G + simazine 4% G	4/1	6/1.5	2.45	2.55

Table 5. Effects of nine herbicides (1 application only) on various weed species of 20 container-grown broadleaf ornamental shrubs.

Weed counts[1]	Rates of Appl. (lb ai/A)	*Cardamine hirsuta* L. (bittercress)	*Oxalis corniculata* L. (weeping woodsorrel)	*Sonchus oleraceus* L. (sow thistle)	*Euphorbia nutans* Lag. (spotted spurge)	*Echinochloa crus-galli* Beauv. (barnyard grass)
control	—	121	76	9	3	2
alachlor 15% G	2	30	67		3	
	4	2	15			
oxadiazon 2% G	2	112	6			
	4	8	2			
oxadiazon 75% WP	2	85	9			
	4	2	14			
oxadiazon 25% EC	2	142	8			1
	4	96	1			
oryzalin 75% WP	2	161	38	1	6	
	4	79	49			
profluralin 2% G	6	108	15			
	9	85	5			
napropamide 10% G	6	68	76		2	
	8	83	33		1	
alachlor 15% G + trifluralin 5% G	4/4	91	39			
	6/6	29	19			
alachlor 15% G + simazine 4% G	4/1	28	125			
	6/1.5	29	85	1	3	

[1] Weed Counts were made 10-11-76, 93 days after the herbicide application.

Table 6. Cumulative phytotoxicity ratings with one herbicide application.

Herbicide	Rate of Application (lb ai/A) Low Rate	High Rate	Phytoxicity Ratings Low Rate	High Rate
control	—	—	0.0	0.0
alachlor 15% G	2	4	0.20	1.65
oxadiazon 2% G	2	4	1.65	2.00
oxadiazon 75% WP	2	4	1.28	1.92
oxadiazon 25% EC	2	4	1.55	2.00
oryzalin 75% WP	2	4	0.21	0.25
profluralin 2% G	6	9	0.50	0.80
napropamide 10% G	6	8	0.90	1.00
alachlor 15% G + trifluralin 5% G	4/4	6/6	1.10	1.15
alachlor 15% G + simazine 4% G	4/1	6/1.5	1.65	1.75

ported severe damage to plant materials with the second application of simazine. Further evaluation of this combination is needed to explore the possibilities of using one initial application of simazine & alachlor followed by applications of alachlor at eight-week intervals.

Using herbicides in a weed control program requires experimentation on an individual basis. A particular herbicide may be suitable for one nursery, while not for another. Growers must consider the variables of their micro-environment, such as soil mixes, amounts of irrigation, plant size, and cultivars to be grown. Fretz (5) reported that the greater the amounts of organic matter in a mix, the higher the concentration of a particular herbicide required for efficient weed control. On the other hand, Carpenter (1) stated that increased porosity of a soil mix also hastened the leaching of the herbicide material into the root zone of the plant. With this in mind, one can conclude that only experimentation is the key to using herbicides for container grown nursery stock.

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WEED CONTROL IN FIELD NURSERY STOCK

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Successful weed control requires an aggressive program directed toward eradication, prevention and control. Emphasis should be placed on *aggressive* because anything less than an all-out attack will not subdue our weed enemy.

[1] Consulting Horticulturist