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

BRYSON L. JAMES[1]

McMinnville, Tennessee 37110

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

Half-heartedly waging war on weeds is expensive and usually leaves our fields miserably infested with weeds. Perhaps it will help to emphasize key points in this review if we can compare tactics and terms used by the military to those needed to successfully fight weeds. Keep in mind that the object is to destroy the enemy while providing safety for your own troops.

FIELD COMMANDER

Every campaign needs a leader. One whose primary responsibility is to win the battle. This leader must not be pulled away to fight other battles such as digging balls, loading trucks, planting, fertilizing or repairing equipment. If your firm doesn't have a weed control General, get one! To fight weeds wisely requires being at the right place at the proper time with effective weapons (herbicides and equipment) that are properly maintained and used. The Company cook can't win the battle for you after supper dishes are washed. The degree of planning and organization and coordination required to wage a successful campaign against weeds deserves the undivided attention of one man.

KNOW YOUR ENEMY

Military intelligence gathering is recognized as the key to winning battles and wars. Recognizing and understanding the habits of weeds is important when planning your attack on weeds. If we will use the things we know about weeds, we can defeat them easily.

1. We know that *weeds will launch two major attacks every year*, spring and fall. By placing land mines (preemergence herbicides) in our fields in the fall before winter annuals germinate and again in the spring before summer annuals germinate, the enemy's two major attacks will be stopped.

2. We know where their *weed factories* are. Some plants have facilities both above and below ground and can survive frequent surface attacks. Elimination of weed seed factories adjacent to the battlefield greatly reduces reinforcement capabilities of our enemy. Perennial weeds such as Johnsongrass, Bermudagrass, nutgrass, artemesia and wild artichoke have extensive underground activities which should be destroyed before sending our own troops (plants) into the field.

3. We know *how weeds are transported*. Mulches and manures, wind, water (rainfall and irrigation) men and other animals and on machinery are the main systems of transportation for weeds. We can influence and/or control most of these systems. Sterilize or don't use weed infested mulches and manures. Use windbreaks to stop many wind-blow seeds. Don't irrigate from ponds and streams surrounded by weeds. Be careful

about moving B&B plants from a field with perennial weed problems to one that is weed free. Wash and thoroughly clean machinery after turning a field with perennial weeds and after mowing a weed field, before going into clean fields.

4. We know *when weeds are easiest to kill*. Annual weeds that escape the preemergence herbicide barrier should be killed when immature. Light cultivation or a weak contact herbicide will do the job. However, perennial weeds and grasses are more easily killed with Roundup (glyphosate) when they approach maturity.

KNOW YOUR OWN "TROOPS" (PLANTS)

Know which plants are most sensitive to chemicals and group similar species together for easy treatment. Avoid intermixing species or otherwise you will be forced to use your weakest herbicide on everything to prevent injury.

KNOW YOUR WEAPONS

There are many good herbicides on the market that are safe for ornamentals when used properly. Time will permit us to talk about only a few of the more widely used products for field nursery stock production. Eight herbicides are discussed at the conclusion of this paper.

Not only do we need to know what weapons to use, we also must know how, when, how much and how often to use them.

A BASIC ATTACK PLAN

After thoroughly studying the weapons (herbicides) available and considering tolerances of your troops (plants), call in your field Commander in charge of weed control and map out a basic plan of attack that will turn back the invasions that you know the enemy (weeds) launches each year. The least expensive and most effective tactic is ambush and surprise attack, so timing is important. Coordinate your efforts with planting, fertilization and cultivation forces so they will not destroy your mine fields (preemergence herbicide barriers).

A typical plan for nurseries in the mid-South is outlined below. Refer to the information at the conclusion of this paper for rates and precautions.

A. **New Plantings**

1. Eradicate perennial weeds and grasses the season before lining out stock. Roundup at 2 to 4 lbs ai/acre (2 to 4 quarts) will do the job. Use the higher rate for Bermudagrass and nutgrass.

2. Incorporate Treflan preplant at 1.5 lbs ai/acre (1.5 quarts). Rototill or disc thoroughly 2-3" deep immediately behind the sprayer. Liners may be planted immediately or delayed a few days or weeks if necessary.

3. Two to three months after planting —

a. Broadleaf evergreens and certain deciduous shrubs. Apply Lasso or Dymid or Enide or Casoron or Kerb or Surflan.

b. Conifers and many deciduous tree species. Apply Princep.

B. **Established Plantings**

1. Fall, cultivate to kill any winter annuals that may have germinated then:

a. Broadleaf evergreens and certain deciduous shrubs. Apply Lasso or Dymid or Enide or Treflan or Casoron or Kerb.

b. Conifers and many deciduous tree species. Apply Princep.

2. Spring, after fertilization and cultivation to remove any existing weed growth:

a. Broadleaf evergreens and certain deciduous shrubs. Apply Lasso or Dymid or Enide or Treflan or Surflan.

b. Conifers and many deciduous tree species. Apply Princep.

PRINCEP (SIMAZINE)

Formulations: 80% Wettable Powder
4% Granules

Toxicity: Acute Oral LD_{50} (rat) over 5,000 mg/Kg.

Crops: Arborvitae, Barberry, Cedar, Cotoneaster, Elm, Fir, Hemlock, Honeysuckle, Juniper, Mahonia, Maples, Oak, Oleander, Pines, Pyracantha, Russian Olive, Spruce, Taxus.

Activity: Preemergence. Apply to weed-free soil to kill grasses and weeds as they germinate. Can be sprayed over the top without crop injury.

— Perhaps the most effective herbicide that can be used with safety on the crops listed above. Controls both grasses and many broadleaf weeds.

— May be combined with many other herbicides.

Precautions: Has a long residual activity and could damage subsequent crops not tolerant to simazine. Also repeated use could cause a build-up.

— Use lower rates on sandy soils and make only one application per year.

— Do not apply more than two times per year on any soil type.

Rates: When used alone, 2 lbs active/Acre (2-1/2 lbs 80W; 50 lbs 4G) on most soils. Use less on very sandy soil and more on very heavy clays and organic soils.

Cost/Acre: About $7.50 for 80W
About $25.00 for 4G

3. Spot treat, using Roundup as a directed spray (on weeds, off nursery stock), to control perennial weeds and grasses and certain annuals that may not be controlled with preemergence herbicides.

TREFLAN (TRIFLURALIN)

Formulations: Liquid (e.c.) 4 lbs/gallon
Granular 5%

Toxicity: Practically non-toxic. Acute Oral LD_{50} greater than 10,000 mg/Kg but LD_{50} of solvent system for e.c. approximately 3,700 mg/Kg.

Crops: Virtually all ornamentals.

Activity: Preemergence, incorporated in weed-free soil will control most grasses and several broadleaf weeds. Weak on broadleaf weeds in general and especially ragweed, jimsonweed, and dock, but it does provide some suppression of Johnsongrass rhizomes.

— Shallow cultivation when applied and several weeks after application may improve effectiveness.

— Best used as a pre-plant, incorporated treatment followed in 2 to 3 months with cultivation and application of another preemergence chemical.

Precautions: Excessive rates and/or very moist soil conditions may cause root-pruning, however, death seldom results from the Treflan alone.

— e.c. formulations must be incorporated promptly to prevent excessive losses.

Rates: 1 to 2 lbs active/Acre (1 to 2 quarts e.c.) when incorporated.

— 3 to 4 lbs active/Acre (60 to 80 lbs 5G) when surface applied.

Cost/Acre: $6.50 to $13.00 for e.c.
$25.00 to $32.00 for granular

LASSO (ALACHLOR)

(NOTE: THIS PRODUCT IS NOT LABELED FOR USE ON ORNAMENTALS)

Formulations: Liquid (e.c.) 4 lbs/gallon
Granular 10% and 15%

Toxicity: Acute Oral LD_{50} (rat) 1,800 mg/Kg.

Crops: Most Ornamentals

Activity: Preemergence primarily but also effective as pre-plant incorporated to control grasses and many broadleaf weeds as they germinate. About the same control as with diphenamid (Enide or Dymid) but costs much less/acre. The e.c. product has shown slight, temporary leaf scorch when applied during moisture stress periods but can generally be applied over the top without crop injury.

Precautions: Do not use in enclosed plastic houses or glass houses.

— Do not use PVC tanks, fittings or nozzles as the solvent softens these materials.

Rates: 4 lbs active/Acre (4 quarts e.c.)

Cost/Acre: About $13.50

DYMID OR ENIDE (DIPHENAMID)

Formulations: 50% and 80% wettable powders
liquefied — 4 lbs/gallon
granular, 5%

Toxicity: Acute Oral LD_{50}, about 1,000 mg/Kg.

Crops: Virtually all commonly grown woody ornamentals

Activity: Preemergence. Apply to weed free soil to kill grasses and many broadleaf weeds as they germinate. Can be sprayed over the top without crop injury.
— Weak on broadleaf weeds, especially summer annuals that germinate more than 6 weeks after application.
— Shallow cultivation does not destroy effectiveness and may benefit when applied during dry period.
— Combination with other herbicides suggested.

Precautions: Very good agitation is required to prevent settling and nozzle clogging due to high rate of wp used/acre. (8 to 16 lbs). Clean strainers and filters frequently.

Rates: When used alone, 4 to 8 lbs active/Acre (8 to 16 lbs 50% w.p. or 5 to 10 lbs 80% w.p.)

Cost/Acre: About $32.00 for w.p.'s.

KERB (PRONAMIDE)

Formulations: 50% wettable powder
Granular

Toxicity: Acute Oral LD_{50} (rat) 8,350 mg/Kg.

Crops: Many ornamentals, not fully tested as yet.

Activity: Preemergence and early postemergence on winter annuals, perennial grasses and certain broadleaf weeds. May be sprayed over the top without crop injury. Kerb is root absorbed. Rainfall or light cultivation is essential.
— Weak on broadleaf weeds in general, but is effective on dock and henbit.
— Combination with other herbicides is suggested for longer residual and more broadleaf weed control.

Precautions: Apply only during the cool seasons. Kerb is not effective during the summer.
— Not effective on organic soils (peat and muck)

Rates: 1.5 lbs active/Acre (3 lbs 50W)

Cost/Acre: About $20.00 for w.p.

DACTHAL (DCPA)

Formulations: 75% wettable powder
Granular 5%

Toxicity: Acute Oral LD_{50} (rat) 3,000 mg/Kg.

Crops: Safe on practically all ornamentals.

Activity: Preemergence control of annual grasses is excellent but is weak on broadleaf weeds. For weed control in species and/or situations that are questionable with other herbicides, Dacthal probably is the safest product to try. Completely safe to apply over the top.

Precaution: Do not disturb soil after application or effectiveness will be destroyed.

Rate: 11 to 12 lbs active/Acre (14-16 lbs 75W)

Cost/Acre: About $30.00

ROUNDUP (GLYPHOSATE)

Formulations: Liquid (e.c.) 4 lbs/gallon.
Toxicity: Acute Oral LD_{50} — 4,300 mg/Kg.
Crops: Use as directed spray *only* around ornamental crops. Not recommended for topical application on any crop, even though some have "gotten-by" with doing so on some plants.
Activity: Postemergence to most broadleaf and grassy weeds. More effective on mature growth, especially for control of Bermudagrass, Johnsongrass, Thistle, Nutgrass, Dock and other perennials.
Precautions: Keep off foliage of crop plants.
Rates: (Commercial Product)
1 fluid ounce/gallon for knapsack sprayer.
4 qts/100 gal — for handgun, high volume.
2 to 4 qts/Acre with boom equipment.
(Lower rates for annual grasses and Johnsongrass and the higher rate for Bermudagrass and Nutgrass.)
Cost/Acre: $26.00 to $52.00

CASORON (DICHLOBENIL)

Formulations: 50% wettable powder
Granular 4%
Toxicity: Acute Oral LD_{50} (rat) 3,160 mg/Kg.
Crops: Most woody ornamentals except hollies and azaleas are tolerant to the lower rate.
Activity: Preemergence on most grasses and many broadleaf weeds from seeds. The granular product applied during the winter will control many hard-to-kill perennial weeds and grasses such as quackgrass, artemesia, dock, fescue and wild artichoke.
Precaution: For best results the granular product should be applied between mid-November and mid-February.
— In warm soils must be cultivated lightly to reduce excessive losses.
— Make only one application/year.
— Careful rate control is necessary to avoid crop injury.
Rates: 4 to 6 lbs active/Acre (8-12 lbs 50W or 100 to 150 lbs 4G) — Use the lower rate for lighter soils and annual weeds and the higher rate for perennial weed control during the cool season.
Cost/Acre: $37.00 to $55.00 for w.p.
$53.00 to $80.00 for 4G

QUESTION: Can you recommend a book or pamphlet that will aid one to identify weeds usually found in southern nurseries.

Yes, there are several: "Weed Identification" published by the University of Georgia Agricultural Extension Service, Hoke Smith Annex, University of Georgia, Athens, Georgia 30602. Another is titled "Weeds of Southern United States"; this should be available from Agricultural Extension offices in all southern states. There is a cost of $.65 for the first-mentioned and $.75 for the latter publication.

MIKE McCALLUM: Do you use any herbicides on your container-grown azaleas?

CURTIS WILKINS: No, we do not use any herbicides on container stock; all the ones we looked at produced too much phytotoxicity to warrant their use on azaleas.

VOICE: Dr. James, did you say that Casoron should not be used on hollies and azaleas?

BRYSON JAMES: I would use it only once per year in the cool season of the year between November and February.

JIM MERCHANT: I know Casoron is very hard on peonies.

VOICE: Our county extension agent did a test with Casoron on rhododendrons in containers during March a few years ago. He used 5 replications of 5 to 25 lbs per acre and got no damage. Weed control was obtained until August. Sidney Meadows, could you comment on what herbicides you use on azaleas?

SIDNEY MEADOWS: We don't use any herbicides on our azaleas. We have tried a few compounds, but we find the best way to control weeds is to exclude them from the nursery as much as possible.

LANNY NEEL: A nurseryman in north Florida I know of has used Lasso sprayed over the top of plants, including azaleas, in his nursery. Initially he was pleased with the results on azaleas, but after several applications found chlorosis and tip die back developing which he attributed to the Lasso.

JIM WELLS: Is anybody using or testing Tenoran? This was written up in The Plant Propagator about a year ago by an Australian who used a wide range of plants and they rated Tenoran No. 1.

BRYSON JAMES: Jim, I've used Tenoran. The main attribute of Tenoran over other herbicides already mentioned is that it controls broadleaf weeds more effectively than the other herbicides. Tenoran is not that safe on ornamentals when used alone at a rate which will control grasses and broadleaf weeds. Used at about 1 lb. active ingredient per acre in combination with one of the other products already mentioned it is effective and safe on at least the conifer and viburnum species I have used it on. It is a good product, but I have found it hard on broadleaf evergreens such as hollies. There needs to be more testing done with this material.

BRYSON JAMES: I have a written question: "How does Kerb kill?" I don't know what system in the plant it disrupts; it is root absorbed and whether or not it disrupts translocation or photosynthesis, I don't know. It kills azaleas though!

LANNY NEEL: Not much is known about specific modes of action of many herbicides. Most can be categorized into groups

such as photosynthesis inhibitors, growth hormones, dessicants, electronic transport inhibitors and so on.

VOICE: Lanny, did the nurseryman in north Florida using Lasso on his azaleas try the granular form also?

LANNY NEEL: I believe he may; but because the liquid form was so much easier to apply, he used it. The phytotoxicity he observed was not a burn from the herbicide, but resulted from damage to the roots over an extended time period.

CHARLIE PARKERSON: This is what Dr. Weatherspoon has been talking about. Let's take a look at it over several applications. Often we will sell our material before applications have a chance to build up. If we were to hold our material a second season we might see more of this inhibition.

BRYSON JAMES: I have another question: What is the best source of information on weed control literature?

I would say probably your own state agricultural extension service. They will have information which is most relevant to your own area. Write to your State University.

CHARLIE PARKERSON: Another good source of up-to-date information is the Proceedings of the Southern Nurserymen's Association Research Conference. This contains current research reports from scientists located in the 13 southeastern states and is an excellent source of information on many topics.

BRYSON JAMES: There is no one good reference that I know of for weed control in ornamentals. I have a question for Curtis: "The container mix is said to be a factor in the translocation and residual nature of herbicides; what was your container mix?"

CURTIS WILKINS: Five parts pine bark, two parts sharp sand, and one part rice hulls; you can see we have no "soil" in our mix. The air space is from 18 to 22% so it is quite porous, which is necessitated by our heavy south Texas rains. This is a contributing factor to the leachability of the herbicides; Lasso is quite leachable in this mix. Ronstar supposedly stays on top of the "soil", but I feel we are still getting some leaching into the root zone which explains the stunting effect we observed.

Another question for Curtis: "What is the effect of age on the effects of these herbicides on the test plants and what was the effect of Lasso on newly planted versus established plants?"

CURTIS WILKINS: When we started the experiment the plants in the one gallon containers were approximately eight weeks old. We observed an initial effect, yes, but as others have found, the larger the established root system the less the effect in older plants.

BRYSON JAMES: I have a question for Charlie: "With formaldehyde, is one week's aeration enough and do you spray everything in the house?"

CHARLIE PARKERSON: We have *Thielaviopsis* problems in the little pots we root in. We root directly in these pots. We put them in, fill them with soil and then seal up the house tight with plastic and spray formaldehyde over everything. Then we close the doors for about a week. After that we go in and knock the soil out of a few pots and smell it. I don't really know how long is enough. It has been recommended that you go in with some tomato transplants when you are ready and observe them for any injury. Our pots are small; larger ones might take longer.

VOICE: Curtis, with your Gandy applicator, do you notice any variation in your application rate depending on the speed of the rig as it is drawn across the bed?

CURTIS WILKINS: No, this is compensated for in the design of the machine; it is chain driven.

JIM WELLS: Curtis, you mentioned two weeds: cress and oxalis, and you said Devrinol was specific for cress. Could you tell us what rate you used Devrinol and how you used it and is there anything specific for oxalis?

CURTIS WILKINS: Our research last year showed that Devrinol was specific for bittercress (*Cardamine hirsutum*) but this year's testing did not substantiate this at all; we got very poor control over the bittercress, but excellent control over oxalis at 6 lbs ai/A.

ROBERT WRIGHT: Bryson, recently I saw a report where the application of Simazine to maples would cause interveinal chlorosis.

BRYSON JAMES: I haven't seen any problem with it on red maple in soils of the McMinnville area, but other people on more sandy soils might have problems with it. Simazine leaches very slowly in the soil and it is this property which makes it selective in most instances. If Simazine does come into contact with roots of ornamental plants, it is usually toxic to the plants and, as indicated, often causes chlorosis.

CHARLIE PARKERSON: Curtis, your paper is entitled, "After Herbicide Trials, a Decision is Made"; did you make one, and are you using herbicides now?

CURTIS WILKINS: Right now Greenleaf (Texas) is using Lasso 15 G at 4 lbs active ingredient per acre. We are not treating azaleas and *Photinia*. We did notice some problems on certain *Euonymus* cultivars, particularly the dwarf ones and also on *Aucuba*. We are applying it every eight weeks with the

Gandy; we don't believe that other applicators are accurate enough.

LANNY NEEL: Dan Weatherspoon has reported root pruning by Lasso after repeated applications with relatively little stunting even after 1/3 of the root system has been killed; the point is, be careful and thorough in your evaluations of any herbicide.

CHARLIE PARKERSON: When we use a preemergence herbicide do we suppress germination or do we kill the seeds?

BRYSON JAMES: When the seed is germinating the herbicide kills the plant. Once the seed coat is broken that seed is killed.

VOICE: Has anyone used Enide before?

BRYSON JAMES: Enide has been on the market for many years and its use on ornamentals has been thoroughly researched; at recommended (diphenamid) rates I have not seen any damage from it (8 lbs active except on a very sandy soil). I have not seen it used on azaleas.

DENNIS McCLOSKEY: If you shouldn't use Pramitol in a nursery under containers, what should you use if roots grow out of the containers?

BRYSON JAMES: I believe that your best bet would be to use a soil sterilizing rate of Simazine (25 lbs/acre of the 80 W).

DENNIS McCLOSKEY: What happens if it leaches into the irrigation water?

BRYSON JAMES: Once it is in the soil, unless it's a very sandy soil, it will not leach and you won't have any problem. A layer of gravel over the soil will provide for drainage. Simazine may be reapplied over the gravel in a year or so and washed down into the gravel where it will again complex with the soil below the gravel and provide a barrier to weed seed germination. If chlorosis develops due to root growth from the containers into the treated soil you can cut the roots and you won't lose the plant. Pramitol poisoning is much worse; by the time you see any symptoms it's too late to save the plant.

JUDD GERMANY: Curtis, have you ever tried pine bark impregnated with herbicide?

CURTIS WILKINS: No.

LANNY NEEL: I have worked with several. Dacthal and pine bark have been marketed under the trade name of Fibrex. We looked at it and found no benefit from added Dacthal when the bark was an inch deep. We also looked at Lasso on pine baka found it to be an effective way to use this herbicide. Using Lasso in this way would add a measure of safety to your pro-

gram because it would be difficult to overdose. You also get the benefit of a mulch. Mechanical barriers such as plastic or fiberglass will suppress weed growth but can interfere with watering and fertilizer placement and don't prevent weeds from growing up around the edges or through holes in them.

BILL CURTIS: Years ago we grew strawberries and I used chloro IPC in the fall with good results. When we got into the nursery business we began using it on our nursery stock in the fall and since then we have had excellent results and no injury to any of our plants. It takes about 30 days to be effective.

BRYSON JAMES: CIPC is an old herbicide, mainly effective on grassy weeds. It is relatively expensive.

LANNY NEEL: Curtis, we used Ronstar on a number of containerized ornamentals and did not get the phytotoxicity which you reported, although Ronstar applied to the foliage is very phytotoxic. I suspect that this difference might have something to do with your growing medium. Ours had "soil" in it whereas yours did not.

LARGE PLANTS IN CONTAINERS

GEORGE L. TABER, III

Glen Saint Mary Nurseries
Glen Saint Mary, Florida 32040

Possibly I should first define "large plants in containers". These are plants that are produced in a manufactured container of at least a 4-gallon capacity. We are currently propagating 90% of the liners we use. From the day the propagation list is prepared, an attempt is made to plan the course of this liner as it moves from the propagation bed to its final planting in the container where it will be grown to maturity. As an example, if our ultimate goal is to inventory 20,000 4-gallon canned *Ilex* and 5,000 15-gallon canned *Ilex*, we will then shift 20,000 rooted cuttings from the propagation bed to pint containers and 5,000 rooted cuttings into 2-gallon containers. These will be staged in holding areas apart from the main growing area and will then be shifted into their respective 4 and 15-gallon containers for growing on. As you can see, there is only one shift process involved and a minimum of handling. Likewise, in planning for 20-24" boxes, we will stage 4 and 7-gallon stock in the holding area. Occasionally there will be two shifting processes when going to extra-large containers.

Unlike many specimen tree nurseries, all of our material has been containerized from the start and has gone the route of the planned series of shifts. The advantages of controlled irriga-