FRIDAY MORNING SESSION
December 7, 1973

DAVE PATTERSON: At this time I want to introduce you to Dr. Tom Fretz, who will be presenting the first paper this morning; he will also serve as moderator for the remainder of the program. Tom will present two papers on herbicides. The first will consider the causes of success or failure with herbicides and the second will be concerned with the use of herbicides for container nursery stock.

SUCCESS OR FAILURE WITH HERBICIDES?[1]

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Most herbicide failures we hear of are not herbicide failures. The conditions under which these materials have been used are usually responsible for the so-called "failures", so often quoted. When you consider all the external forces that can ultimately affect herbicidal action, it's a miracle they work at all.

The ultimate fate of an herbicide once introduced into the environment can be seen in Figure 1. Three major degradation processes and six transfer processes play a role in determining the fate of these chemicals. *Biological decomposition* or breakdown by living organisms; *chemical decomposition*, the breakdown by chemical processes in the absence of living organisms; and *photodecomposition*, the degradation by chemical processes involving radiant energy, are the three processes by which herbicides are degraded and their chemical composition changed.

The major transfer processes which affect herbicides in the environment include absorption by plants and animals, retention in vegetation and ultimate transference in the harvested product, adsorption by soil particles, movement through the air and into the atmosphere by volatilization, surface runoff into water sources and movement in soils, either as a liquid or a gas.

Not only are there numerous environmental factors which are involved in herbicidal action, but the chances for human

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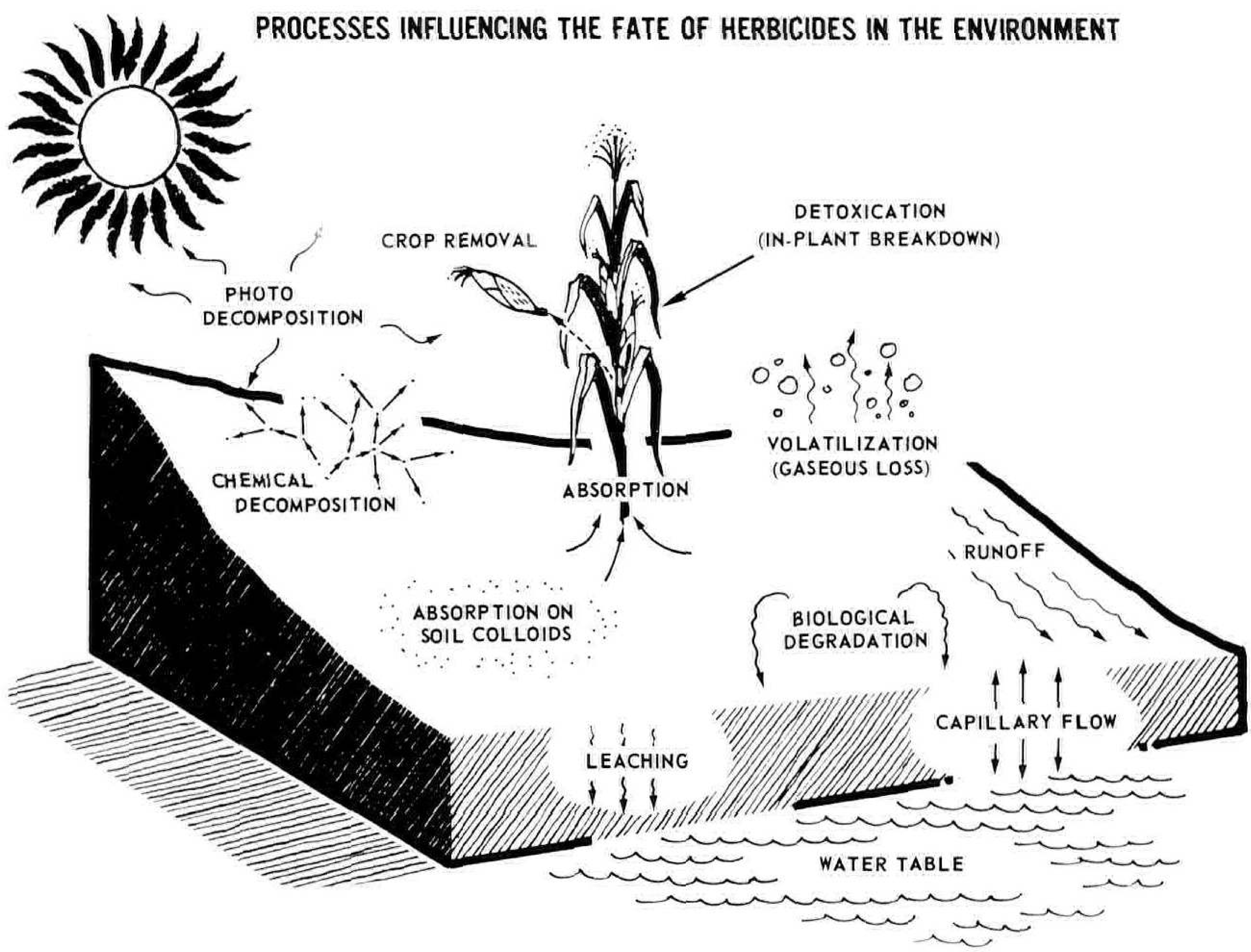

Figure 1. Processes influencing the fate of herbicides in the environment.

error are present from the inital steps of selection through application and crop management. The discussion which follows is not meant to be an excuse for past failures, but to draw attention to the variables so that future failures can be avoided.

THE WEEDS

Proper herbicide selection is extremely important in achieving a successful weed control program, be it corn or nursery crop production. It must always be remembered that herbicides are very selective, and while some control annual grass weeds, others control only annual broadleaf weeds. Still other herbicides have a relatively broad spectrum in terms of weeds controlled.

Knowing the weeds which are present in a particular situation will ultimately help in choosing the proper herbicide for the job. Table 1 is presented as a guide to the intelligent selection of herbicides for control of particular weed species. For example, selecting DCPA (Dacthal) for control of annual broadleaf weeds, almost certainly will result in erratic results.

In addition to considering the major weed species present in the nursery, one must think of increasing weed resistance follow-

Table 1. Weed species response to herbicides [1]

HERBICIDES	Weed Groups													
Common Name and Trade Name	Amaranthaceae (Pigweed Family)	Chenopodiaceae (Goosefoot Family)	Compositae (Daisy Family)	Cruciferae (Mustard Family)	Gramineae (Grass Family)	Leguminosae (Pea Family)	Malvaceae (Mallow Family)	Solanaceae (Nightshade Family)	Euphorbiaceae (Spurge Family)	Polygonum aviculare (Smartweed)	Portulaca oleraceae (Purslane)	Stellaria media (Chickweed)	Convolvulus arevensis (Bindweed)	Cyperus sp (Nutsedge)
Alachlor (Lasso)	*	0	0	0	*	0	0	*	X	0	*	?	0	X
Chlorpropham (CIPC)	*	*	X	*	*	*	X	*	0	*	*	*	0	0
DCPA (Dacthal)	X	*	0	0	*	0	0	X	*	X	*	X	0	0
Dichlobenil (Casaron)	*	*	*	X	X	X	*	*	X	*	*	*	*	*
Diphenamid (Dymid or Enide)	*	X	X	0	*	0	X	0	0	X	X	*	0	0
EPTC (Eptam)	*	X	X	0	*	0	0	*	*	*	*	X	0	*
Linuron (Lorox)	*	*	X	*	*	X	X	*	?	X	*	*	0	0
Simazine (Princep)	X	*	*	*	0	?	X	*	0	*	*	*	0	0
Trifluralin (Treflan)	*	*	0	0	*	0	0	0	X	*	X	*	X	0

[1] From — Lange, A H , 1971 *Agrichemical Age*, Vol 14(4) 5

Key 0 = not controlled, X = partial or erratic control
* = controlled

ing the continual application of a single herbicide. Nearly every nurseryman can cite examples of elimination of annual weeds only to be overrun with perennials. For this reason, the alternating of herbicides, development of an "Herbicide Program", and the use of combinations should be carefully considered.

THE CROP

An herbicide may effectively control weeds in one crop while severely damaging another crop. For example, dichlobenil (Casaron) may be used very effectively on juniper without injury but may cause severe damage on Japanese holly. The application of herbicides to various crops is by far the most exacting task the grower has to perform. The aim is to injure or kill one plant (the weed) while at the same time not injuring another plant (the crop).

Once a grower has decided on the herbicide which is specifically labelled for use on the crops and has an exact knowledge of the weed spectrum involved, he is ready to apply a material which is tailor made for the job.

INFLUENCE ON FOLLOWING CROPS

Some chemicals break down due to biological, chemical, or photodecomposition more readily than others. This may be either an advantage or disadvantage for the nurseryman depending on his cropping system. The advantage would be in terms of full season weed control while a disadvantage would result if either a crop rotation or winter cover drop is used in the nursery. Where a crop is to be removed at the end of the season and replanted, careful selection of the herbicide used in terms of the next crop must be considered. Perhaps where this type of a situation exists, growers should consider planting fields in terms of specific herbicide tolerant crops; for example, blocks of land where only *Taxus* or other simazine-tolerant crops will be planted.

If one uses a system of cover crops during the autumn and winter for winter protection of newly-planted nursery crops in the first or second growth years to prevent soil heaving, selection of the herbicide program must be carefully scrutinized in order to prevent herbicide damage to the cover crop.

TIME OF APPLICATION

Every herbicide has an optimum application time. Preplant herbicides such as trifluralin (Treflan), are applied prior to the planting of the crop, while preemergence herbicides, such as diphenamid (Dymid or Enide) are applied before the weeds emerge from the soil. With nursery crops we generally think of preemergence herbicides as being used on established crops prior to weed emergence. Postemergence herbicides are applied after the weeds have emerged from the soil.

Examples of correct time of application affecting herbicide performance should be familiar to all nurserymen. Dichlobenil, for example, must be applied at temperatures below 50°F (preferable during the winter) to achieve the desired weed control. In addition, we might cite chlorprophram (CIPC) as an herbicide from which a grower can suffer great losses due to wrong time of application. This material is labelled for use on dormant plants and if applied during active growth can cause severe injury.

Likewise, time of application in terms of weed seed germination can greatly affect the herbicide response. For example; simazine application during the winter after the emergence of the cool-season broadleaved weeds will be ineffective, but if applied in the early fall prior to their germination, successful control will generally result.

Thus using the herbicide in the proper manner, at the right rate, and at the proper time can help to insure the best results.

AMOUNT OF HERBICIDE USED

Herbicides often have a very narrow range of activity, between acceptable weed control and crop injury. Few herbicides can be used at excessive rates to insure weed control without causing undue hazard to cultivated crops. As an example, simazine may be used at rates of up to 25 to 30 lb. a.i./A on *Taxus* without injury but the same material at 4 lb. a.i./A will almost certainly injure deciduous species such as *Forsythia* and *Potentilla.*

SOIL TYPE

While herbicides are sold nationwide, no two soil types react exactly the same when it comes to herbicide performance; the triazine herbicides are more effective in clay type soils, while trifluralin and related herbicides are more effective in sandy soils.

In addition, control with the preemergent herbicides can be influenced by various soil surface conditions. For these materials to work best, not only is a weed-free soil surface necessary, but the soil should be freshly tilled or disked. Also of importance, particularly when granular materials are used, is for the soil surface to be relatively smooth in order to achieve a uniform distribution.

So, regardless of the claims made for a new herbicidal material, each grower should examine the material for 2 to 3 years on small areas to ascertain just what it will do under his soil conditions, which will vary in terms of soil organic matter, soil texture, weed spectrum, rainfall pattern, method of application, crop, and cultural practices.

SOIL ORGANIC MATTER

More than any other soil constituent, soil organic matter content determines the activity of herbicides in the soil. If soil organic matter is ignored, be prepared for erratic results from herbicides.

Table 2. Relative absorption of herbicides by soil organic matter [1]

None	— Dalapon; Paraquat
Weak	— CDAA (Randox); Propachlor (Ramrod), Chlorambem (Amiben)
Moderate	— 2, 4-D
Strong	— Alachlor (Lasso); Diphenamid (Dymid or Enide), Dichlobenil (Casaron); EPTC (Eptam; Simazine (Princep), and Terbacil (Sinbar)
Very Strong	— Diuron (Karmex), Linuron (Lorox), Chlorpropham (CIPC); DCPA (Dacthal), Trifluralin (Treflan)

[1] *From. Warren, G.F 1973 Action of herbicides in soil affected by organic* matter *Weeds Today* Vol 4 (2)·10-12

The importance of organic matter lies in its capacity to attract and hold a variety of molecules through the process of absorption or, more simply, the sticking of the chemical to the surface of the organic matter so that the molecule is not free to move in the soil solution and is thus less available to be taken up by plants.

The relative absorption of some common herbicides by organic matter is listed in Table 2. With nursery soils, especially those used in container production containing large quantities of organic matter, the weakly absorbed herbicides are largely in the solution phase and are readily leached out of the root zone, while the strongly absorbed herbicides give the longest period of weed control due to their strong attachment to the soil organic matter.

Often the strongly absorbed herbicides in these high organic matter soils work to the detriment of good weed control as application rates may be so high they either become uneconomical or exceed the legal limits suggested by the manufacturer. For example, trifluralin must be increased in its rate of application in order to achieve weed control in soils that have high amounts of organic matter (Table 3). In studies of container-grown nursery stock, trifluralin is often used in a range of 4 to 8 lb. a.i./A in order to achieve satisfactory weed control, primarily due to the large quantity of organic matter in the medium.

Table 3. Rate of trifluralin required to achieve desired weed control in soils of varying organic matter [1]

Percent Organic Matter in Soil	Trifluralin, required/A (lbs/Active)
1	1/4
2	1/2
3	3/4
4	1
6	1-1/2
8	2
16	4

[1] From Warren, G F., 1973 Action of herbicides in soil affected by organic matter *Weeds Today*. Vol. 4 (2) 10-12.

WEATHER CONDITIONS

Temperature and moisture have a great deal to do with the success or failure of an herbicide program. Once it is understood how these two factors can influence the killing action of an herbicide one can better decide the kind, amount and best time for application of herbicides.

Actually it is remarkable that weed control successes are as frequent as they are, if we stop to consider the great differences in weather conditions under which these chemicals are applied in the commercial nursery operation. Temperatures may vary from 40° to 100°F; soil moisture from air-dried to flooded; relative humidity from 10 to 100%; sunlight from 1,000 to 10,000 foot candles; and wind from 0 to 50 mph. Under these unpredictable weather conditions, we spray a few ounces of chemical on a half-million or more weeds per acre and the majority of time are rewarded with profitable weed control.

Many things must happen in order for a postemergent herbicide spray to kill weeds. The spray droplets must be caught and held by the leaf surface. Then the chemical must penetrate the leaf surface, often through a waxy surface barrier and move through the plant to the point where some killing action occurs. Temperature and moisture affect the herbicide and the plant, before, during and after the spray application.

TEMPERATURE

Postemergence herbicides generally perform best at warmer air temperatures. The major effect of temperature in this case is on the rate of uptake of the herbicide into the plant. This effect is offset to some extent by the increased rate of drying of the herbicide spray at higher temperatures, as once the spray dries, the penetration of the herbicide into the plant is reduced. Generally, since faster herbicide movement into the plant is favored by high temperatures, more favorable weed control can be obtained if the temperature is high at the time of application.

In addition, the thickness and chemical composition of the cuticle of the leaf surface can be influenced by temperature conditions ultimately affecting postemergence herbicide uptake. Cool night and moderate day temperatures often favor this increased cuticle thickness in some weed species, thereby reducing postemergent herbicide penetration.

Not only does temperature affect herbicide uptake, but temperature can have pronounced effects on the dissipation or losses of herbicides from soils through volatilization and degradation.

Likewise preemergence herbicides perform best at soil temperatures that favor weed seed germination and rapid growth. Cool soil temperatures that delay weed seed germination can reduce preemergent herbicide effectiveness markedly.

In addition, herbicides such as EPTC and trifluralin evaporate readily and their losses as vapors are quite rapid at high temperatures. Obviously such losses can reduce their weed controlling action. In the case of trifluralin and EPTC these volatilazation losses can be decreased by cultural practices, such as physically incorporating them into the soil. Apparently the quicker a volatile herbicide is incorporated into the soil after application, the better. From a practical standpoint, herbicides which must be incorporated into the soil to be effective have a limited application on established nursery stock. Since dichlobenil (Casaron) is so volatile at soil temperatures above 50°F, its use is limited to late fall and winter applications.

Soil temperature can also influence how quickly non-volatile herbicides become inactivated. Atrazine, for example, is rapidly converted by chemical reaction to hydroxyatrazine in moist soils above 75°F, while inactivation is very slow below this temperature. This helps to explain why atrazine residues are not as serious in the southern U.S. as they are in the more northern climates.

MOISTURE

Adequate soil moisture prior to the time of herbicide application stimulates uniform and vigorous growth of weeds. Application of preemergent herbicides under these conditions are thus more likely to succeed than when the soil has been dry at the time of treatment. Dry conditions cause uneven weed seed germination. As a result, proper timing of the preemergent spray application is difficult at best.

Humidity at the time of herbicide application also influences the ultimate weed control especially with postemergent materials. With high relative humidity more herbicide penetrates the leaves and more weeds are killed. Leaves in low relative humidity absorb less herbicide, thereby reducing the plant response.

Heavy rainfall shortly after a foliage application of herbicide may wash the chemical off the leaves before it can be absorbed. The most critical period for rainfall is probably within the first half hour after application.

For preemergence herbicides, rainfall is essential for satisfactory responses. Rain will carry most herbicides into the top 1/2 inch of the soil where the maximum number of weed seeds germinate. A delay in rainfall of more than a few days following application may reduce the degree of weed control. With irrigation systems this effect may be overcome rather easily. For many of the preemergent herbicides, a period of 10 to 14 days without rain following application often causes complete failure. During such a dry period, the herbicide may be destroyed by exposure to sunlight while it lies on the soil surface, or weeds may germinate and emerge without taking up the herbicide.

Heavy rainfall of several inches or more; soon after preemergent application can be detrimental. It may carry the herbicide beyond the depth of the weed seed or may be removed from the site of application by excessive runoff.

SUNLIGHT

Photodecomposition by exposure to ultraviolet light affects many herbicides. Some preemergent herbicides must be immediately incorporated into the soil to prevent this type of breakdown. At the other extreme, some preemergence type herbicides can be left on the soil surface until rainfall or irrigation carries them down to the zone of weed seed germination with no photodecomposition. Even shallow cultivation of these more or less stable herbicides apparently doesn't decrease their effectiveness.

HERBICIDE PROGRAMS

The ideas conveyed so far have dealt with the reasons for successes or failures with herbicides in the past. The key words which we should be using are "Herbicide Programs". Nurserymen should strive for a program of selected materials applied singly, or in combination, in order to achieve year-round weed control. The need in most nursery operations is for fall or early winter applications to remove the winter broadleaf weeds, followed by spring or early summer applications to remove annual and perennial weeds. Many nurserymen do nothing with herbicide programs during the summer months, using the excuse that they want to keep the labor force busy during a relatively slow period during the year. Robbing nursery stock of valuable water and nutrients as a result of unnecessary weed competition and thereby reducing overall growth, just to keep the help busy is certainly not a very valid justification.

In addition, it should be pointed out that observation is an important key to the use of herbicide programs. The nurseryman should not be looking for 100% year-round control with his program, which could result in eventual soil sterilization, but year-round control more in the range of 95%. Thus by carefully observing when weeds are beginning to reinfest a treated area, carefully timed reapplications can be planned.

SUMMARY

This discussion at least calls attention to the fact that herbicides are not perfect. Weather, soil texture, temperature, weed spectrum, soil organic matter, crop, and many other factors alone, and in combination, influence herbicide performance year after year. There may be seasons when, because of these factors, individual herbicide performance varies. But cultural control also varies year to year, so don't give up on herbicides just because of one bad experience.

HERBICIDE COMBINATIONS FOR WEED CONTROL IN CONTAINER NURSERY STOCK[1]

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Abstract. Herbicide combinations were effective in reducing weed growth in container-grown nursery stock. Trifluralin at 4 lb. ai/A and alachlor at 1 5 lb ai/A gave excellent grass weed control, but poor control of broadleaf weeds Linuron at 1 0 lb, ai/A exhibited excellent broadleaf weed control but poor control of annual grass weeds When linuron at 1.0 lb ai/A and trifluralin at 4 0 lb ai/A were applied in combination, excellent control of both annual broadleaf and grass weeds was observed.

INTRODUCTION

With the increased emphasis of growing nursery stock in containers, a viable program for weed control is essential. Over the past several years a great deal of information has been pub-

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