FIELD RESEARCH METHODS FOR STUDYING WEED CONTROL IN NURSERIES

An outline of various treatment techniques and evaluation methods to help nurserymen in their own operations

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Weed control in nurseries is more complicated than the situation associated with most agronomic crops. Instead of large monocultures, nursery fields generally contain several species of plants in immediate proximity. These plants may have different growth habits and may differ in sensitivity to particular herbicides. Tolerance not only may differ between species, but may also vary for cultivars within a species.

Ornamental woody plants may remain in the field from 3 to 10 years or longer. This makes deep cultivation and other mechanical control methods impractical or impossible. Hand weeding is used to a large extent in many nurseries, but because of increased labor costs and problems, does not present an economic solution to weed problems. The number of herbicides currently labeled for use in ornamental crops is but a small fraction of those available for use in agronomic crops.

These problems are not unique to the production of woody ornamental plants but are common among nurseries producing seedlings, field grown fruit trees, forest species, chrysanthemums, and ornamental bulb, corm, and rhizome crops. This paper explores field research methods used by weed control researchers.

Much of the research published results from work carried on by university staff and extension personnel, and to some extent, pro gressive growers. Field experiments may be performed at university facilities or at producing commercial nursery locations. The general aim of all this research is maximum control of weeds with minimum damage to the crop.

Woody Ornamental Nursery Corps

Techniques described in this section will include those used in studying weed control in field grown ornamental nursery stock.

Tolerance of different species to specific compounds is an important area of past and current research. This is often accomplished by the "squirt and look" or the "spray and pray" techniques. Various rates of herbicides may be applied to several species and types of ornamental plants. In one experiment, Runge (*39*) used 27 different species of deciduous and evergreen trees and shrubs. The materials may be applied over or across (*11*) rows or blocks.

Visual rating systems are the most common means of evaluating tolerance or injury (*13, 10, 11, 12, 18, 29, 44, 9, 1, 2*). Rating systems vary with individual researchers (0 to 9, 0 to 10, or 0 to 100, etc.), however, most establish a commercially acceptable level, below which plant tolerance or weed control is too poor for economic use in commercial operations.

Bennett (*8*) examined the toxicity of several herbicides and herbicide combinations on various newly planted nursery species. He examined possible synergistic relationships of various herbicides when applied with simazine. These combinations were applied to species known to be sensitive to simazine and visual ratings of toxicity symptoms were made.

Fresh weights of the crop or other growth measurements may be taken and compared to controls as an indicator of possible phytotoxicity. Growth measurements have included length of the growing shoots of shrubs (*1*) and caliper (trunk diameter) and height for shade trees (*38*).

Weed counts may be separated into broadleaves and grasses or may be cataloged by individual species. This provides information on control of specific weeds and on changes in weed populations over a longer period. Plots may be cleaned after weed counts to provide information on regrowth and durability of the chemicals. Total and individual weed counts are generally expressed as a percent of the check.

Pre- and post-planting treatments of liner (young nursery stock) has been extensively studied. Liner areas contain large

numbers of plants with limited root systems (*44*). Preplanting treatments have been used to rid an area of weed problems prior to planting (*1, 17, 29, 4*). Evaluation may include survival of liners or rooted cuttings (*17*), weed control ratings, weed counts, growth measurements, and fresh weights of the liners and weeds. Post planting applications are generally evaluated by the same techniques.

Cost comparisons of hand weeding and herbicides are frequently used in older literature and in current studies. This information is important and provides tangible evidence to present to growers.

Perennial weeds are often a problem in nurseries. Continued use of preemergent herbicides often eliminates competition to perennial weeds, and populations then tend to increase. Long term cropping prevents fallow-cultivation control methods, and many ornamental species are very sensitive to growth regulator herbicides. General and specific control of perennial weed problems has been researched (*4, 29*). Evaluation techniques are similar to those described earlier, with special attention paid to control and regrowth of the perennial weeds.

Container Nurseries

The number of nurseries producing ornamental plants in containers is growing. Of the $40 to $42 million woody ornamental industry in Florida, 85 to 90 percent is produced in containers (*21, 49*), These statistics are similar for California.

Weeds adversely affect container grown plants by reducing their dry weight and the fullness and quality of the crop (*27*). Cultivation is impossible and hand weeding is very expensive (*40*). Padgett and Frazier (*36*) reported hand weeding of an acre of one gallon containers (30,000 containers per acre) required 624 man hours. Six applications of herbicide (10 pounds active ingredient/acre) cost $550 per acre, compared $3600 required to hand weed an acre of containers (*20*). The cost of weed control amounts to approximately 20 percent of the total annual wholesale sales volume (*41*).

Soil is seldom used as a container growing medium because of potential drainage problems and shipping weight. Artificial medias may consist of various combinations by volume of some of the following: perlite, vermiculite, sand, soil, mined clays, peat, bark, humus, and flyash. The specific components of a mixture depend on the geographic location of the nursery and the availability and the cost of the individual constituents. The medium is generally porous, however. Container plants are usually irrigated at least once a day.

Herbicides have been incorporated in the media (*14, 35*), incorporated in mulch and applied to the containers (*35*), and applied as liquids and granules over the top of the containers after planting. Weed seeds are often seeded after application. Evaluation techniques are as varied as the researchers involved. Periodic weed counts, cataloguing by species, and fresh weights are popular methods for testing weed control. However, weed vigor, shoot and root fresh weights (*35*), and weed control ratings (*26, 28, 24*) have also been used.

Crop tolerance is critical in container production. Severe injury may result from the movement of herbicides into the restricted root zone (*33*). Visual ratings of fullness and quality of the crop (*28*) and of the phytotoxic effects of the material (*21, 48, 24, 27, 28*) have been used to give qualitative measurements. Dry weight (*26*) and fresh weights of the crop (*14, 25, 48, 20, 40, 49*) have been used to provide more quantitative results of crop effect. Curry (*20*) studied the growth characteristics of crop roots by a water displacement technique.

Growth indexes have been used to evaluate crop tolerance (*49, 24*). Such an index is established by multiplying the height by the diameter and dividing by 2. This measurement may provide a truer evaluation of the effect of herbicides on the marketable qualities of container grown plants.

Carpenter (*14*) mixed activated carbon with the potting media to protect plant roots from herbicides. Herbicides were also mixed with planting media and a 2.5 cm layer applied over the activated carbon mix. Growth of the crop in the carbon containing pots was superior to the controls.

Effect of Herbicides on Propagation

Rooting potential is another criterion that may be used in assessing herbicidal safety to ornamental plants. Cuttings taken from field and container stock plants treated with various herbicides are rated by the incidence and extent of rooting and compared to cuttings from untreated plants.

In general, there was no consistent effect on the rooting of most ornamental plants tested (*2, 46, 47, 6, 17*). However, (*47*) found the rooting of *Calluna vulgaris* 'Aurea' increased when stock plants were treated with certain herbicides and decreased when the stock plants were treated with other herbicides.

Fruit Tree Nurseries

Fruit trees are often produced by budding desirable selections into field grown seedlings. Cultural techniques are otherwise similar to field grown ornamental crops. Curtis (*22*) studied the effects of terbacil on budding and field production. The herbicide was applied as seedlings emerged the first season and during the budding the second year. Weed counts were made and species identified to evaluate control. The stand of seedlings was noted at time of application and compared to the stand at budding. The number of scions beginning growth and the number and size of saleable trees was recorded. All data from herbicide treatments was compared to that of a control.

The long term effect of herbicides from nursery to planting area was evaluated by comparing caliper growth, time of first fruit, and initial and subsequent yields (*43*).

Other evaluation methods of weed control and tolerance of fruit trees to herbicides nursery production are similar to those described earlier.

Forest Nurseries

Forest nurseries are concerned with producing seedlings and liners for reforestation of public and private lands, land reclamation, and conservation purposes. Research in this area is greatly interested in the effect of herbicides and weed control in seedbeds and on the growth of liner stock. Herbicides have been tested pre- and post-planting or seeding; fumigants are used prior to seeding (*42*). Evaluation of plant growth has been made by measuring current growth of terminal shoots, mortality, incidence and degree of leaf dieback (*32*), seedling stand, seedling fresh weight at end of season (*19*), and comparison of seeding sizes, grades, and total yield (*30, 42*). Weed control has been evaluated by the same methods as described earlier.

Iyer (*30*) compared the nutrient status of the soil after seedling harvest in herbicide areas to controls. Foliar analysis of the plants was also compared.

Chrysanthemums (Chrysanthemum moriflorum)

Research involving pre- and post-planting applications of herbicides in chrysanthemum field production has been carried on for a number of years (*1, 3, 4*). Rooted cuttings are planted in the field in early spring and dug for fall sale. Cutting blocks may also be maintained in the field.

Weed control data consists of weed counts (general and by species) and visual ratings. Plant tolerance is evaluated by visual ratings, fresh weights, and number and size of the flowers. Activated carbon root dips have been used in mechanical transplant operations to achieve more protection from preemergent herbicides (*4*).

Ornamental Bulb, Corm and Rhizome Crops

Long term weed control in ornamental bulb, corm, and rhizome crops is desirable because of the poor ground cover of the crop, even at maturity. The leaves of these crops also die relatively early in the season. Cultivation may increase the incidence of disease that results from wounding. Weed competition causes reduction in bulb size and presents difficulties during harvesting.

Weed control data collection is similar to that discussed for other crops. Phytotoxic effects on gladiolus has been determined by recording the number, weight, and date of cutting of flower spikes (*10*). Corms may be harvested and weighed (*5*) and number of cormels counted (*10*). To determine residual effects, corms have been replanted in the same plot and the same factors as above evaluated during the second year (*10*).

The effect of herbicides on different stages in the development of tulip bulbs was studied by Jones and Haddow (*31*). Visible crop damage was assessed on a rating system. Quantitative measurements included flower stem length, corolla size, and leaf numbers. Evaluations of corolla size and stem length were made on field growth the second season and on greenhouse forced bulbs. Effects of herbicides on narcissus production by the same researchers proceeded in the same manner as above. However, in addition to corolla size and stem length, the corolla diameter was also measured.

In work with *Iris germainca*, Einert and Talbert (*23*) selected uniform rhizomes of the cultivar 'Amethyst Flame' for their herbicide work. Pre- and post-planting treatments were compared to weeded and nonweeded controls. Weed control, injury symptoms, and weeding times were recorded monthly. Measurements of the winter survival of the rhizomes and flowering characteristics were made.

Milbocker (34) selected rhizomes randomly from unnamed plants to assure maximum genetic variation. Weed counts, leaf symptoms, and rhizome weights were recorded.

Application Techniques

Application techniques vary with the type, size, and location of the study and the equipment available. Knapsack and CO_2 powered sprayers are the most common methods of applying herbicides in water carrier. Granules may be applied by impeller (cyclone) or drop (Gandy-type) spreaders, or in the case of some container work, by shaker cans. Standard nursery equipment is often used for on site or large field experiments.

Incorporation may be by mechanical means or by irrigation. Herbicides may be incorporated into container media and mulches by hand or by soil mixing machines.

Test plant species vary greatly. Selection seems to primarily depend on the section of the country and the predominance of particular plants in the associated industries.

Experimental Design and Statistical Inference

The most common experimental design used in field and container experiments was a randomized complete block. Blocking, in most cases, is probably to overcome variation in soil and artificial media, application techniques and equipment, and plant material. Complete random-

ized designs are occasionally used in container research (*27*).

Duncan's new multiple range test and least significant difference (LSD) were the most common methods of analysis of variance between treatments found in the literature. LSD is generally misused, in that comparisons made are those suggested by the data. For confidence levels to be valid, the LSD test should be used only for independent or non-independent comparison planned before the data have been examined (*45*). Duncan's multiple range test is used correctly and is very sensitive to small differences among treatments. However, it is probably the least conservative method of analysis, and significant differences derived by this method may not be apparent when the data are analyzed by other methods (Tucky, Dunnett's, etc.). Dunnett's multiple range test is used occasionally (*49*), as are factorials (*35*).

It would appear that the choice of statistical methods may be somewhat dependent on the statistical training of the researcher, the statistical resources available, and the number of significant differences desired.

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