

Herbicide use for weed control in avocado culture

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SYNOPSIS

Herbicides have been developed for use in avocado culture to either replace or supplement other weed control methods such as hoeing, tillage and mowing. Residual, soil-active, preemergence herbicides provide long-term control of weeds arising from seeds. Postemergence contact herbicides control annual weeds that escape soil residual herbicide treatment. Foliar-active, translocated herbicides may be used to control perennial weeds. The best combination of herbicides varies with orchard conditions. Proper co-ordination of herbicide and other weed control methods is required to obtain maximum benefits from, and to reduce problems associated with, each method of weed control. Benefits derived from proper use of herbicides are varied. Herbicides can be used where cultivation is not possible or desirable. Injury to trees by equipment is reduced. Destructive effects of tillage on soil structure is decreased and soil erosion is less than for tilled soil. Orchard management and pest control are easier in non-tilled orchards without cover crops. Problems from misuse of herbicides may also occur. These include poor weed control, tree damage, injury to non-target organisms and contamination of the environment.

INTRODUCTION

Research has been done on the use of herbicides for weed control in avocado culture in California. The project has continued for about 30 years and has included over 100 herbicides. The research has involved all aspects of herbicide development, ranging from greenhouse screening to field efficacy trials, residue analysis and developing recommendations for avocado growers. The basic research procedures have remained the same with minor changes, made as needed to fit different field or laboratory situations.

GREENHOUSE SCREENING

Small avocado plants, about 30 cm tall, are placed in containers with a standard soil mix. Soil residual herbicides are mixed directly into the soil, while various concentrations of foliar-active herbicides are sprayed directly onto the leaves. The plants are rated for herbicide symptoms and harvested for weight and size measurements.

FIELD TRIALS

Three-tree replicated plots are established in 3- to 10-year-old orchards. The herbicides are applied at different rates, either directly to the soil or to the weeds up to 5 m on each side of the base of trees. Trees are visually rated for injury symptoms and fruit are collected as needed at various intervals for herbicide residue analysis.

RESULTS AND IMPLEMENTATION OF RESEARCH

Useful results from the numerous herbicide trials will be summarised in this manuscript, instead of providing many tables concerned with individual experiments. The summaries will cover soil residual, contact and translocated herbicides.

SOIL RESIDUAL HERBICIDES

Those that may be used in avocado culture, include diuron, napropamide, norflurazon, oryzalin and simazine.

Each herbicide has a spectrum of weeds that it controls and other weeds that are either partially controlled, or not at all. They are applied directly to the soil surface and moved into the soil, where they kill weed seedlings.

Diuron (N'(3,4-dichlorophenyl)-N,N-dimethylurea) - this may safely be used as a pre-emergence application to the soil surface for the control of many annual weeds. Registration of diuron use in avocados is being considered by the United States of America regulatory agencies. The herbicide must be moved into the soil either by rainfall, or overhead irrigation within one month after application to achieve maximum weed control. Avocado foliage sprayed with the herbicide may be damaged under high temperature conditions; also when a surfactant is added to the spray mixture to increase contact activity to small annual weeds. Diuron should not be used near avocado trees grown in very sandy or gravelly soils with low organic matter content, since severe injury may occur to the trees. While diuron controls many annual broadleaved and grassy weeds, it does not control some of the Medicago and Euphorbia species.

Napropamide (N,N-diethyl-2-(1-naphthalenyloxy)propanamide) - this is a relatively unstable pre-emergence herbicide. Controls weeds best if incorporated into the soil by either rainfall or sprinkler irrigation within three days after application. Fall applications followed by rainfall, are more effective than spring applications. About 2 cm of water after application, provides adequate movement of the herbicide into the soil. Too much water immediately after application, may reduce weed control. Herbicide injury has not been noted, even on newly-planted trees. Napropamide does not control some cool-season, winter-annual weeds such as those in the Cruciferae family and it is weak on some summer annuals such as those in the Solanaceae family. The herbicide has desirable soil-residual properties and controls most annual grasses very well. Repeated annual applications suppress *Cyperus esculentus*.

Norflurazon (4-chloro-5-(methylamino)-2-(3-(trifluoromethyl)phenyl)-3-(2H)-pyridazinone) - this is being considered for registration for use in avocado culture in the United States of America. It is a pre-emergence herbicide that requires incorporation into the soil, using over 2 cm of water either by overhead irrigation or rainfall. Young trees may be damaged in very sandy soils with low organic matter content. The herbicide effectively controls annual grassy and several broadleaved weeds and

suppresses some important perennials. Several common broadleaved weeds, however, are not controlled by this herbicide.

Oryzalin (4-(dipropylamino)-3,5-dinitrobenzenesulfonamide) - this is a relatively broad-spectrum pre-emergence dinitroaniline herbicide. It does not require mechanical incorporation, if either rainfall or overhead irrigation occurs within 30 days after application. The amount of water required for best weed control varies from 1,5 to 5 cm, depending upon soil conditions, mainly texture. The herbicide leaches only a short distance into soils. Trees are not injured by the herbicide, even in sandy soils with low organic matter content. Some weeds in the Cruciferae and Compositae families are only partially controlled by oryzalin.

Simazine (6-chloro-N,N'-diethyl-1,3,5-triazine-2,4-diamine) - a symmetrical triazine, it is widely used in avocado culture. It is relatively non-volatile, has low water solubility and low toxicity to organisms without photosynthetic mechanisms. The herbicide is applied to the soil surface and must be moved into the soil by either overhead irrigation or rainfall within one month after application. Simazine is not toxic to avocado foliage and is safe to use around established trees in sandy loam or heavier soils with more than one per cent organic matter. Simazine does not completely control some summer annual grasses. Other weeds in the Amaranthaceae, Chenopodiaceae and Compositae have developed resistance to simazine after several years of repeated use.

CONTACT HERBICIDES

These are used to control weeds that escape soil residual herbicide treatments. They are effective against small annuals, but do not control perennial weeds. Weed oil was once the most widely used contact weed control agent, but since the oil price has increased, use of weed oil declined and other contact herbicides, such as paraquat, have replaced it.

Paraquat (1,1'-dimethyl-4,4'-bipyridinium ion) - a post-emergence contact herbicide, it gives best control of annual weeds when they are in the two- to four-leaf stage. Older weeds require higher herbicide rates and the addition of a surfactant for adequate control. Best results are also obtained under low-light conditions and during warm weather. Weeds that are stressed and those with waxy and hairy surfaces, are sometimes tolerant to paraquat. It is compatible with many soil residual herbicides and can be used as a tank mix to control growing weeds. The herbicide damages avocado trees if it comes into contact with the foliage or green bark. Paraquat is toxic to humans and must be used with caution.

TRANSLOCATED HERBICIDES

These herbicides are used to control annual and perennial weeds that escape soil-residual and contact herbicides. They can move from the point of application throughout the entire plant and into the underground portions and, thus, kill persistent perennials. Although many translocated herbicides have been tested for use in avocado culture, only a few are both effective and safe enough for general use.

Fluazifop (+)-2-[4-[[5-(trifluoromethyl)-2-pyridinyl]oxy]phenoxy]-propanoic acid) - this is one of the herbicides being developed to be used specifically for grass control without damage to broadleaved plants. It can be applied directly to the foliage of avocados without injury to the trees. Grasses under environmental stress are difficult to control, therefore they should be vigorously growing when the herbicide is sprayed to the foliage. After tillering and seedhead formation control is substantially decreased, addition of either a crop oil concentrate or non-ionic surfactant is often required for best herbicidal activity.

Glyphosate (N-(phosphonomethyl)glycine) - it can control virtually any weed if directed treatment onto weed foliage is possible. Contact of the herbicide with the foliage or green bark of most plants can result in serious damage. Avocados are somewhat tolerant to glyphosate and minor contact through drift or minimum spray to the lower foliage does not cause severe damage. Glyphosate injury symptoms appear slowly and may not occur for several days, either on the avocados or weeds. Plants that are either under moisture stress, or in a dormant state, are difficult to control with glyphosate. Single glyphosate treatments will kill most simple annuals, but repeated treatments are required for control of perennial weeds. Even though glyphosate is a translocated herbicide, virtually none of the parent chemical and its primary metabolite have been found in avocados treated under field conditions.

HERBICIDE COMBINATIONS

These are used when individual herbicides do not control the weeds at rates safe for the trees. When annual weeds escape a soil-residual herbicide, different choices are available:

- (1) Combination with another soil residual herbicide to broaden the spectrum of weeds controlled. Combinations of simazine with either diuron, flurazon or oryzalin, may be used to take advantage of the weed control spectrum of each herbicide, while the dosage levels of all are retained at the minimum required for best results.
- (2) Addition of a contact herbicide such as paraquat, to control annual weeds that escape the residual herbicides.
- (3) Post-emergence treatment with a translocated herbicide to control difficult annual and perennial weeds that are established in the orchard. Glyphosate mixes well in sprays with several of the soil-residual herbicides and thus it is possible to control germinating weeds by the soil-residual herbicide and growing weeds by the translocated herbicide.

HERBICIDE ROTATION

This is best practised for taking advantage of the best weed control properties of each herbicide, to avoid increased populations of weeds that are tolerant to the herbicide and to prevent the build-up of weeds that become resistant to specific herbicides. An example of a typical herbicide rotation includes the following sequence:

- (1) Early in spring, glyphosate is applied to control established weeds.

- (2) Late in spring, diuron is applied to control early season germinating grasses and some broadleaved weeds.
- (3) During early to mid-summer, paraquat is applied to control annual weeds that escaped the diuron treatment.
- (4) Early fall applications of simazine are made to control germinating broadleaved weeds. At this time, the surviving perennial weeds are treated a second time.

Variations in the use of chemicals and the time of their application will be used in different orchards depending upon weeds and environmental conditions.

GENERAL CONSIDERATIONS

Weed control programmes involving herbicides in avocado culture, require careful advance planning and continual monitoring to achieve maximum effectiveness. A first consideration involves the type of weeds present and their susceptibility to the herbicides available for use in the orchard. The nature of the soil should also be considered, since herbicides leach more in sandy soils than in heavy clay soils. Their persistence is shorter in soils with high organic matter and in environmental conditions that favour microbial decomposition of the herbicide. Crop damage from soil-residual herbicides is more likely in sandy, low organic matter soils.

The physiological status of the plants will also affect herbicide toxicity. Time of application of post-emergence herbicides is often critical for best weed control. Young, vigorous, rapidly growing plants are generally easier to control than old, mature and stressed plants. Translocated growth regulator herbicides, such as glyphosate, should be applied to perennial weeds when photosynthates are moving into the underground portions of the plants. Soil-residual herbicides that are transported in the xylem, will move more rapidly to the leaves when conditions are favourable for water movement throughout the plant.

When the same herbicides are applied to the same field for several years, the tolerant and resistant weeds become more prevalent. Avocado orchards should be monitored periodically to determine the nature of the vegetative shift. Herbicides used should be changed as necessary to maintain control of the shifting weed population. Perennial weeds will become the dominant vegetation in orchards repeatedly treated with soil-residual herbicides alone. Some grasses will increase in simazine-treated orchards. Herbicide rotation and combination may be used to overcome many of the problems associated with weed population shifts.

CONCLUSION

Herbicide programmes for complete weed control in avocado orchards are feasible, especially if used in conjunction with other available weed control methods that are adapted to the locality.