periments to confirm effectiveness on Florida grapevines are incomplete. Well established control methods are still adequate for most grape pests, while some improvement in control of leafhoppers may be possible as a result of research described here.

Little attention has been paid to grape seed chalcid as a grape pest because there have been no recent problems and no significant outbreaks in commercial plantings. Indeed there have been no large plantings of susceptible grapes. However, as those plantings (such as 'Stover' for wine) increase, so may the pest potential of this insect increase. The wild host Virginia creeper is abundant in Florida. Control strategies have been developed.

In central Florida, flights of grape root borer moths are much later than in north central Georgia. In Georgia pupal development and adult emergence can be correlated with % sugar in 'Concord' grapes (7) and both are completed in August before grape harvest. In Florida, peak emergence of root borer moths occurs in early October after all bunch grape and nearly all muscadine grape harvest is complete. Vineyard sprays directed at adult moths and newly hatched young larvae, if adopted as a control strategy, will need to be timed differently in Florida than in Georgia.

Recommendations for the control of grape diseases are available (10, 16). With all bunch grapes except 'Blue Lake', a dormant application of liquid lime-sulfur is recommended. However, recent tests at the ARC Leesburg have shown that applications of benomyl or captan after bud-break may be as good or better than dormant sprays for anthracnose control. This application is primarily to "clean-up" the old wood; therefore, care must be taken to thoroughly wet the entire grapevine. This dormant or bud-break fungicide treatment is not necessary on muscadines.

The regular spray program on bunch grapes should begin in the spring when buds are 2-6 inches long and be continued at intervals of 10-14 days until harvest. Benomyl, maneb + zinc, captan, and folpet are effective on grape foliar diseases. Since the activity of these fungicides against specific diseases varies, it is advisable to use combinations of materials in a grapevine disease control program. As examples, benomyl could be tank mixed with either captan or maneb + zinc, folpet could be alternated with maneb + zinc, or folpet could even be alternated with benomyl plus maneb + zinc. Such a program should control all of the fruit rots and leafspot diseases of grape in Florida. After harvest, spray every 3-4 weeks to control premature defoliation.

With muscadines, the first fungicide spray should be applied just prior to bloom and applications continued every 14 days until 7-10 days prior to harvest. The primary problem is bitter rot, so the spray just prior to ripening is most critical. The fungicides are the same as for bunch grapes.

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GRAPE WEED RESEARCH AND RECOMMENDATIONS[1]

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Abstract. **Weed control in vineyards can be accomplished by several methods. Mulching, hand hoeing, and minimal herbicide use is generally recommended for the homeowner. In a commercial vineyard a no-till system consists of a closely mowed sod middle with a herbicide strip maintained under the trellis. Use of a treehoe or rototiller is not recommended in a commercial vineyard since damage can occur to the vine and/or trellis. Many factors affect choice of herbicide for use in the vineyard such as soil type, vine age, and target weed species. If one heeds the influence of these factors, it will greatly facilitate correct herbicide**

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choice. Paraquat and glyphosate, two postemergence herbicides, provide short-term broad spectrum weed control. Simazine and diuron are standard preemergence herbicides which have some limitations but are less expensive than the safer, more recently developed herbicides such as napropamide and oryzalin. While any single herbicide may give acceptable weed control, tank mixes are the most desirable method of commercial weed control.

Weed control is one of the most important cultural practices in a vineyard since weeds can compete for nutrients, water and sunlight, harbor insects, and serve as a source of diseases. This can ultimately reduce yield quantity and/or quality. There are several methods of weed control, all of which have distinct advantages and disadvantages.

Mulching. Use of mulches can have more positive ramifications than simply providing adequate weed control. Moisture conservation and soil buildup of organic matter result from mulching. Nutrients, such as nitrogen, are also released from decaying mulch.

Homeowners generally find mulching one of the easiest and safest methods of weed control. Organic mulch material can come from any number of sources—pine needles, other leaves, grass clippings, straw, pine or cypress bark, etc. When using grass clippings care should be taken not to include mature weed seed. Another precaution when mulching is to insure that the mulch is pulled back 6-8" from the vine. This will eliminate the possibility of mulch causing winter injury. Though mulching has generally been confined to homeowners and small acreage, at least one north Florida grape grower uses mulch from crimson clover grown in the vineyard.

Cultivation. This type of weed control takes many forms. Manual hoeing is generally confined to homeowners and in low acreage vineyards since it is laborious. Mechanical cultivation in medium and large vineyards can be performed by mowing, rototilling or use of a treehoe. Mowing the row middles is the best way to manage this vegetation. However, mowing is not an effective method of weed control under the vine since it only reduces the size of the weeds. Rototilling and treehoeing can cause severe damage to bunch and muscadine vines and to muscadine root systems. All 3 means of mechanical weed control can damage the trellis system.

Chemical weed control. The best, most commonly recommended system of vineyard floor management is a no-till system. This system includes a mowed sod middle with a herbicide strip beneath the trellis. Usually, the herbicide is applied using a tractor-mounted apparatus including a tank, pump, pressure regulator, and either a boom or handgun each with a herbicide spray tip.

There are many important considerations in choosing the correct herbicide for the vineyard. Soil type is one critical factor since sandy soil, which makes up a good portion of Florida's soil, will physically allow certain herbicides to leach more deeply. This moves the compounds out of the weed seed germination zone and into the grape root zone where high rates of some herbicides could cause injury. Sandy soils generally contain less organic matter than silt or clay soils. Herbicides can chemically bind with the organic matter and reduce the possibility of injury to the vine.

Label recommendations usually suggest the lower limit rate of herbicides to be used on sandy soils low in organic matter. Some herbicides due to chemical composition and water solubility have more potential to cause injury because of leaching than others. Simazine will leach in sandy low organic soils and cause injury to younger vines, especially if under sprinkler irrigation (11). Lange, et al. also state that treatments to newly planted vines in sandy soil with 4 to 8 times the recommended rate of oryzalin resulted in stunted growth.

Vine age is another important factor in herbicide selection. Some herbicides, like diuron and simazine, can not be applied to grapes less than 3-yrs-old. Napropamide can be applied to a vineyard after the first year. While dichlobenil has only a 4 week after planting waiting period, oryzalin can be used as soon as the soil has settled following transplanting of the vine. Glyphosate can be used for site preparation prior to transplanting and anytime after the vineyard is established. Paraquat has no limitations on timing of application.

Weather conditions are important since some herbicides, such as napropamide and oryzalin must be incorporated or irrigated into the soil if ¼ to ½" of rainfall does not occur within 1 or 21 days after application, respectively. On the other hand, paraquat and glyphosate need drying time to be completely effective. Paraquat needs only to dry while glyphosate requires 6 hours of drying before rainfall or irrigation can occur to be effective. Another weather factor to consider in herbicide applications is wind. High winds can cause damage to the foliage and fruit from spray drift and result in an irregular spray pattern.

The type of weed to be controlled determines choice of herbicide. Generally, there are 3 types of weeds present in a vineyard. Annual broadleaf weeds such as eveningprimrose, sicklepod, redroot pigweed, etc. and annual grasses, for example, sandbur, crabgrass, and goosegrass are 2 types of weeds. The most persistent of the 3, the perennial, includes bermudagrass, bahiagrass, nutsedge, and vines such as blackberry and bindweed.

During the year the target weed species will change. Annual broadleaf weeds generally are more troublesome in the spring with annual grasses and perennials more of a problem in the summer. Therefore, timing of application is important. The initial treatment of preemergence herbicides (herbicides that control weed seedlings before they emerge above the soil) should be sprayed prior to spring so that rainfall can move these chemicals into the weed seed zone by the time spring weeds are germinating. Postemergence herbicides (herbicides which control weeds after they have emerged through the soil) are used to temporarily clean up existing vegetation which has escaped control by a preemergence herbicide. Usually, a second application of preemergence herbicides can be tank mixed with a postemergence herbicide if increased weed control is needed in mid-summer.

Postemergence herbicides. There are 4 herbicides which have appreciable postemergence activity that are registered for use in the vineyard—paraquat, glyphosate, dinoseb, and diuron (Table 1). Paraquat when applied to succulent weed growth 1-6" high will desiccate the treated weeds provided there is thorough coverage using 50 to 200 gallons

Table 1. Herbicides currently registered for use in Florida vineyards.[z]

Common name	Trade name	Manufacturer
Dichlobenil	Casoron	Thompson-Hayward
Dinoseb	Dow General Weed Killer	Dow
Diuron	Karmex	E. I. duPont de Nemours
Glyphosate	Roundup	Monsanto
Napropamide	Devrinol	Stauffer
Oryzalin	Surflan	Elanco
Paraquat	Paraquat	Chevron
Simazine	Princep	Ciba-Geigy
Trifluralin	Treflan	Elanco

[z]There maybe more than one trade name or manufacturer of a product.

of water per acre and a spreader used such as X-77® (8 oz/100 gals). A 2 lb active ingredient (ai) per gallon product in a concentrated liquid formulation, paraquat is recommended at 1 to 2 quarts or 0.5 to 1.0 lb ai per treated acre. Annuals can be controlled by paraquat, but since paraquat only desiccates that portion of the plant sprayed, the roots of perennials will permit resprouting after several weeks. Balerdi applied paraquat 2 or 3 times a year for 4 years with no phytotoxic effects and no decrease in trunk diameter, fruit yield, or prunings (lb/vine) compared to an untreated check (5).

Glyphosate is a nonselective postemergence herbicide. It differs from paraquat in its method of weed control. When glyphosate contacts any green tissue, leaves or stems, it is absorbed by that tissue and translocated throughout, killing the entire plant.

Glyphosate becomes inactivated in the soil by binding to clay or organic matter (18). Since Florida soils are generally low in both these characteristics, glyphosate may not be rapidly inactivated. Therefore, glyphosate, depending on several factors, may result in slight preemergence weed control. According to studies, the control of these weeds would be due to inhibition of shoot elongation rather than inhibition of seed germination (8, 9, 18).

Glyphosate has been tested extensively for many crops (1, 2, 14, 16). Experimentation on grapes has been reported in several states (7, 13, 15). Lange et al., after 3 years of field and greenhouse testing in California, stated in 1975 that glyphosate causes more damage on Thompson Seedless than many other postemergence herbicides when sprayed directly on the foliage or through drift (13). These researchers found that if glyphosate contacted the tips of vines, it injured buds along the entire vine the following spring. Glyphosate was taken up by buds and branches of young grapes due to the low profile. However, when sprayed only to the lower 12″ of 3-yr-old vines with rates up to 16 lb ai/A, it did not reduce vine growth the following spring.

Glyphosate and paraquat differ in another property. Glyphosate has its own wetting agents but additional use of a non-ionic surfactant is recommended at ½% v/v only when using 50 or more gal/A of water. However, Lange et al. reported increased control of some weeds such as bermudagrass by adding low rates of X-77 (13). Another study using ^{14}C-glyphosate also showed AG-98®, a surfactant, increased absorption in Texas Blueweed (6). The product label, as well as Lange et al., also stress that unfavorable growing conditions for weeds such as drought, frost, or insect attack and dust on the weeds can reduce the effectiveness of glyphosate (13).

On muscadines, glyphosate at 4 lb ai/A has proven a valuable tool in controlling perennial weeds resistant to preemergence herbicides such as simazine (7). As in the above study, glyphosate caused injury to first leaf vines due to contact with the basal leaves. However, it took 9 lb ai/A to elicit this response. Phytotoxicity was manifested as partial defoliation and malformed growth with no carryover effect the following years. Trunk diameter, yield, and soluble solids were unaffected by 2 applications of up to 9 lb ai/A to 2 or 3-yr-old vines. Also, as in the study of Lange et al., the tolerance of older vines was due to the bark acting as a barrier. A 1973 grape herbicide trial by Mortensen suggested glyphosate would become an accepted weed control tool at 2 and 4 lb ai/A when registered (15).

Glyphosate is a 4 lb ai/gal water soluble liquid. Application is recommended at 2 to 4 lb ai/A (not to exceed 10.6 lb ai/A/yr) in 20 to 60 gals water/A at pressures and with nozzle types which will not result in drift of fine particles or splattering. Treatment less than 14 days before harvest is not permitted. Glyphosate may be used for land preparation or in established vineyards if extreme care is taken not to contact any green foliage, green bark, suckers, or vines and replants less than 3-yrs-old.

Dinoseb (5 lb ai/gal) has clearance for use as a postemergence herbicide on 2-yr-old and older vines with the restriction of no application within 30 days of harvest. Rates of 1¼ to 2½ lb ai/A are advised with the addition of 10 to 20 gals of diesel oil or weed oil in enough water to make 100 gals. Up to 4 applications/yr may be made. This mixture should be applied to succulent weeds no higher than 6″ at 100 to 150 gals/A. The spray should not contact the foliage, blossoms, or fruit clusters, although it may be sprayed on the base of the crop plant stems. A study in California on *Vitis vinifera* concluded basal applications of dinoseb at 2 gals/A plus 4 gals oil at or before bloom should be sufficient to control weeds until the grapes shade the vine row (19).

Diuron, an 80% wettable powder formulation which is cleared for use at rates of 1.6 to 2.4 lb ai/A in vineyards at least 3-yrs-old, is somewhat unique in that it has postemergence and preemergence activity. Though mainly studied for its preemergence activity, diuron has some burndown capability, especially when applied to succulent weed growth during high humidity and temperature 70°F and above. Use of a surfactant such as WK® increases the effectiveness of diuron.

Several other herbicides which have postemergence activity such as terbacil, dalapon, and amitrole have been studied for use in vineyards (5). 2,4-D and MSMA were evaluated in another study (12). Currently dalapon and oxyfluorfen are cleared for use in vineyards in other states but not in Florida.

Preemergence herbicides. As mentioned above, preemergence herbicides are those which control certain germinating weed seed. Each preemergence herbicide controls only certain weeds; therefore, these herbicides are also called selective herbicides. Currently, 6 preemergence herbicides are registered for use in Florida's vineyards—simazine, diuron, dichlobenil, napropamide, oryzalin, and trifluralin (see Table 1).

Simazine is one of the standard herbicides for use in the vineyard. Simazine has proven toxic to newly planted dormant cuttings or rooted cuttings of Thompson Seedless at rates of 2 and 4 lb ai/A (12). However, at another location in this same study, up to 8 lb ai/A was non-toxic. Generally, 2 lb ai/A was safe. When applied to mature bunch grapes on fine sandy soil, Balerdi concluded simazine at 3 lb ai/A and up was more effective against broadleaf weeds than perennials with no crop phytotoxicity (4). Simazine, in an 80% wettable, a 4 lb ai/gal liquid, or a 90% water dispersible granule formulation, is recommended at rates of 2 to 4.8 lb ai/A (depending on soil type) to 3-yr-old or older vines.

Diuron has been used as a herbicide in vineyards for many years. One study by Land and Daniell states diuron at rates up to 9 lb ai/A did not provide effective weed control (10). However, in a second experiment, Balerdi concluded diuron was, in general, slightly better than simazine in controlling weeds (4). He reported diuron at 3 lb ai/A was as effective as 4 or 6 lb ai/A except on bermudagrass. An 80% wettable powder, diuron is registered for use at 1.6 to 2.4 lb ai/A on 3-yr-old or older vines on soils low in clay or organic matter (1 or 2%). Vineyard soils high in clay or organic matter can be treated with 2.4 to 4.8 lb ai/A. Severe plant injury may result if a heavy rainfall or more than 1″ of irrigation occurs shortly after application.

Dichlobenil, a 4% granule or a 50% wettable powder has

clearance for use in Florida vineyards. Two studies have shown dichlobenil to be effective against broadleaf weeds at 4 lb ai/A (4, 5). Dichlobenil is cleared for use in bearing, non-bearing, and nursery stock with a waiting period on application of 4 weeks after transplanting. Weed control of annuals and perennials with the 4 G formulation is obtained with 100-150 and 150 lbs/treated acre, respectively. A 4 to 6 lb ai/A rate is recommended for the 50 WP formulation. Both formulations need to be incorporated in the soil in Florida. The label cautions that dichlobenil should not be used on light sandy soil such as 'St. Lucie' or 'Arzell' fine sand.

Trifluralin, a 4 lb ai/gal emulsifiable concentrate, has clearance only for preplant application, if incorporated, in Florida. Work in California has shown trifluralin effective in preplant applications but incorporation in vineyards especially after heavy rains is difficult (11). This study also showed that when soil treated with high rates of trifluralin was used to back fill around roots of newly planted vines, temporary stunting occurred. In a later test, trifluralin gave good to excellent weed control at 1 lb ai/A and did not result in phytotoxicity even at rates up to 4 lb ai/A (12). The registered rates of trifluralin depend on soil texture and ranges from ½ to 1 lb ai/A. At least one incorporation into the soil is required within 24 hours and if the first incorporation does not move the herbicide 2 or 3 inches below the soil surface a second is needed.

Napropamide, a 50% wettable powder, has only recently been registered for use in Florida for preemergence weed control in vineyards at least 1-yr-old. A study by Lange et al. has shown that napropamide has a place in the arsenal of weed control since it is relatively non-toxic to grapes even at high rates (11). A rate of 4 lb ai/A is recommended for control of some annual broadleaf weeds and grasses. Unsatisfactory weed control with napropamide has been reported with the 3 main reasons being 1) resistant weeds, 2) herbicide loss from volatilization or extended delay between application and rainfall or irrigation, or 3) application to moist soil without follow-up irrigation prior to weed seed germination (11). In order to insure complete effectiveness, napropamide must be incorporated or irrigated into the soil if sufficient rainfall to wet the soil 2 to 4" does not occur within 24 hours. Because incorporation is difficult and hazardous to the vines and trellis system, and since most Florida vineyards are not under irrigation, timing of application with respect to rainfall is critical.

Oryzalin, either as a 75% wettable powder or a 4 lb ai/gal aqueous suspension, has recently been registered for use on bearing as well as nonbearing grapes. Testing has shown oryzalin to have many of the same characteristics as napropamide (11). It is extremely safe with stunting being reported only after rates of 16 lb ai/A were applied. Oryzalin, though nonvolatile, requires irrigation if a ½" rain has not moved it into the weed seed zone within 21 days after treatment. Oryzalin weed control is rate dependent in that 2 lb ai/A will provide control up to 4 months, while a rate of 4 lb ai/A will give effective control of 46 different annual grasses and broadleaf weeds for 6 to 8 months.

Tank mixes or combinations. The combining of more than one preemergence or a post- and preemergence herbicide is permissible as long as the rate of each specific herbicide is not higher than allowed singly. Tank mixes are generally suggested over the use of one particular chemical, except when only postemergence weed control is desired. Tank mixing is done in order to increase the spectrum of weeds controlled, since all herbicides do not control the same weeds. Tank mixes have been tested widely combining various herbicides at different rates (4, 5, 7, 10, 11, 12).

Not all tank mixes are recommended due to certain problems, in particular incompatibility. Studies have reported antagonism of preemergence herbicides, such as simazine, on glyphosate (3, 17). It was concluded that the reduction in glyphosate activity by simazine was due to a physical binding within the spray solution instead of a biological interaction in the plant (3). The antagonism reported by Selleck and Baird was on perennials and not on annuals (17). They found increasing the rate of glyphosate reduced the antagonism. It should be obvious that all tank mixes are not feasible, since many may interact to reduce the weed control efficiency. Always check the labels for compatability of a product with other herbicides and fertilizers.

One of the most important aspects of a weed control cultural management program is the cost. Some costs of a few herbicides below reflect that price may be the most important factor to the grower in choosing a herbicide and rate. The cost, quoted recently by a regional pesticide supplier, of 2 lb ai/A of napropamide was $27.24, glyphosate $40.95, diuron $10.88, and simazine $9.88. With this in mind, a herbicide trial at the Agricultural Research Center in Monticello, FL may be evaluated with respect to economics. The preemergence herbicide combination of diuron and simazine at 1 lb ai/A was the most cost efficient even though the 2 lb ai/A rate resulted in slightly better overall weed control.

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