Table 6. Muscadine and bunch grape cultivars tested but not recommended for new plantings in Florida.

Black muscadine grapes	Reason not recommended
Bountiful	Fruit falls to ground early
Creek	Low sugar; high acid; female
Dulcet	Low yield; very wet scar; female
Duplin	Lacks quality and yield
Hunt	Low yield; dry calyptras; female
Magoon	Fruit too small; vines weak; some PD
Pride	Susceptible to PD
Scott Imperial	Female; berries too small
Sugargate	Very low yield; some PD; dry calyptras
Thomas	Lacks flavor; female
Bronze muscadine grapes	
Carlos	Susceptible to PD
Chowan	Low yield
Dearing	Low yield
Higgins	Fruit rots; ripens unevenly; female
Lucida	Susceptible to PD
Magnolia	Fruit rots; ripens unevenly
Nevermiss	Low yield; female; lacks quality
Pamlico	Low yield
Pink Hunt	Lacks quality; mediocre; female
Redgate	Tight bunch; wet scar; low taste rating
Rich	Low yield
Roanoke	Low yield
Scuppernong	Low yield; some PD; female
Sterling	Weak vine growth; unadapted
Stuckey	Low yield; female
Topsail	Low yield; female
Watergate	Low to medium yield; female
Yuga	Small berry; tenacious; female
P.D.-resistant bunch grapes	
Black Spanish (Lenoir)	Lacks fruit quality
Delaware	Lacks vine vigor and yield
Herbemont	Lacks fruit quality
Norris	Subject to fruit crack & anthracnose
Roucaneuf	Lacks fruit quality; some PD
Seminole	Lacks fruit quality
Stover Tetraploid	Lacks vine vigor and yield
Tropico	Adherent pulp; lacks quality
Valhallah	Lacks fruit quality

Fla. State Hort. Soc. 79:390-395.
5. ———. 1971. Breeding grapes for central Florida. HortScience 6:149-153.
6. ———. 1978. Grape varieties recommended for Florida. Leesburg ARC Research Rept. WG 78-1.
7. ——— and C. F. Balerdi. 1973. Muscadine grapes for Florida: yields and other characteristics of 48 cultivars. Proc. Fla. State Hort. Soc. 86:338-341.
8. ——— and N. C. Hayslip. 1977. 'Welder' muscadine grape. HortScience 12:267-268.
9. ———, W. B. Nesbitt, and V. H. Underwood. 1976. Dixie, a bronze muscadine grape variety. Fla. Agr. Exp. Sta. Circ. S-244.
10. ———, L. H. Stover, and C. F. Balerdi. 1977. Sources of resistance to Pierce's disease in *Vitis*. J. Amer. Soc. Hort. Sci. 102:695-697.
11. Overcash, J. P., C. P. Hegwood, Jr., and B. J. Stojanovic. 1981. Mid-South and MissBlue, two new bunch grape cultivars. Fruit South 5(2):6-11.
12. Stofella, P. J., J. A. Mortensen, N. C. Hayslip, and J. B. Brolmann. 1981. Muscadine grape cultivar yield trials at Fort Pierce, Florida. Ft. Pierce ARC Research Rept. RL 1981-5.
13. Stover, L. H. 1960. Progress in the development of grape varieties for Florida. Proc. Fla. State Hort. Soc. 73:320-323.
14. ———, J. M. Crall, and J. A. Mortensen. 1977. Marketing Florida bunch grapes as fresh fruit. Proc. Fla. State Hort. Soc. 90:228-230.

Proc. Fla. State Hort. Soc. 94:331-336. 1981.

GRAPE INSECTS AND DISEASES IN FLORIDA[1]

W. C. Adlerz and D. L. Hopkins
University of Florida, IFAS,
Agricultural Research Center,
P.O. Box 388, Leesburg, FL 32748

Additional index words. Grape seed chalcid, grape leafhopper, grape flea beetle, grape root borer, Pierce's disease, black rot, bitter rot, downy mildew, *Isariopsis*.

Abstract. **Insects having the greatest potential for reducing yields of grapes or of killing grapevines have received most attention in studies of ecology, biology, and control. These include grape seed chalcid,** *Prodecatoma cooki* **(Howard), grape flea beetle,** *Altica chalybea* **Illiger, grape leafhopper,** *Erythroneura comes* **(Say), grape root borer,** *Vitacea polistiformis* **(Harris), and two vectors of Pierce's disease (PD) bacterium** *Oncometopia nigricans* **(Walker) and** *Homaladoisca coagulata* **(Say). In this paper control methods are reviewed for grape flea beetle and grape seed chalcid and newly described for grape leafhopper, while recent ecological studies needed to schedule control efforts are described for grape root borer. Ecology and epidemiology of PD bacterium relative to two leafhopper species are discussed. Presently resistance to the bacterium, derived from wild grape species, is the only control for PD.**

Anthracnose development in the spring was delayed and greatly reduced by dormant or early bud-break application of liquid lime sulfur, benomyl, captafol, or captan. Benomyl, maneb + zinc, folpet, and captan all provided some control of the grape foliage diseases. For overall disease control, combinations or alternate applications of these materials have been most effective.

Many insects affect production of Florida grapes, especially bunch grapes. They include both incidental pests such as grape phylloxera, various leaf galling insects, and grapevine aphids, and more common but easily controlled minor pests, such as the grape leaf skeletonizer and grape leaf folder. These have received little attention in our research program.

Research emphasis has been placed on the grape leaf-

[1]Florida Agricultural Experiment Station Journal Series No. 3403.

hopper, *Erythroneura comes* (Say), which reduces vine vitality and fruit quality, grape flea beetle, *Altica chalybea* Illiger, and grape seed chalcid, *Prodecatoma cooki* (Howard), which reduce marketable berries, and grape root borer, *Vitacea polistiformis* (Harris), which reduces yields and may kill both bunch and muscadine grapevines. It was necessary to study seasonal activity of adults of the grape seed chalcid and the grape root borer to properly time control efforts. Intensive investigations were made of the ecology of two larger leafhoppers that breed on grapevines, because they are vectors of Pierce's disease (PD) bacterium, a killer of susceptible bunch and muscadine grapevines. Grape cultivars with resistance to PD must be used in Florida. The grape industry in Florida is based on cultivars derived from resistant *Vitis* species that are native to the Gulf Coastal Plain of the Southeastern United States (17).

Fungal disease control is a necessity for successful bunch and muscadine grape production. Anthracnose (*Elsinoe ampelina* [d By.] Shear) is the most damaging fungal disease of bunch grape in Florida, affecting both fruit and foliage. High temperatures, abundant rainfall, and high humidity during fruit maturation make fruit rots a problem on both bunch grapes and muscadines. Several leafspot diseases which are insignificant early in the season begin to occur in July and August. Control of these diseases is important to assure that vines entering dormancy will be strong and healthy and produce good yields the following season.

Materials and Methods

Seasonal life history and control studies of the grape seed chalcid were conducted on grapevines in a dooryard planting at Wildwood, Florida. Grape flea beetle and grape leafhopper control studies were evaluated at the ARC Leesburg research farm. Grape root borer control studies have been initiated at a commercial vineyard near Kathleen, Florida. Ecological studies on the root borer were conducted there and at the laboratory farm. PD vector leafhoppers were studied at various Lake and Sumter county locations on grapevines, citrus trees, and on associated weeds. Details are included under separate categories in the results section.

Chemical control of fungal diseases on grapevines was evaluated in the ARC, Leesburg vineyard. The dormant fungicide test in 1980 and the fruit rot fungicide test in 1981 were done on selection 'L9-11' bunch grapes. All other fungicide tests were conducted on selection 'F4-36'. Details of the tests are given in the results section.

Results

Grape Seed Chalcid

The grape seed chalcid was first detected in Florida in a dooryard planting of 'Blue Lake', 'Lake Emerald', and other grapes at Wildwood where it was especially damaging on 'Blue Lake' (1). Damage consisted of small "shot holes" that appeared suddenly just before harvest. Seeds were mined and the fruit pulp was traversed by tunnels of the emerging wasps and up to 99% of 'Blue Lake' bunches sustained damage.

Seasonal distribution of adults was determined by suspending 5 x 10-inch yellow boards coated with Stickem Special under the vines (2). Wasps were active from late April to mid July with peak activity the last week in June. Bagged bunches of grapes exposed at intervals of 1 week were infested by chalcids only the first 3 weeks of May (Table 1). Malathion was effective in controlling adult wasps. At harvest, the ratio of undamaged to damaged 'Blue Lake' grape bunches was 0.4/1 in unsprayed and 6.8/1 in sprayed vines. When necessary, weekly spraying from late April through May is recommended for control (3).

Grape seed chalcid damage to grapes was observed in 6 of 9 counties surveyed and on 4 bunch grape varieties, Virginia creeper, *Parthenocissus quinquefolia* (L.) Planch, and *Vitis shuttleworthi* House (2).

Grape Flea Beetle

The grape flea beetle is usually the first insect observed damaging grapevines in the spring. Adult metallic blue beetles about 1/5 inch in length feed on buds and unfolding leaves and may do extensive damage by reducing primary buds as they emerge from the canes.

Beetles mate on the grapevines and females lay eggs in bark crevices, at the base of buds, between bud scales, and on leaves. The resulting small, brown, black-spotted larvae feed for 3-4 wks on the vines, skeletonizing leaves, and eating flowers and flower buds thus directly affecting yields. Although a potent economic threat to production, little study has been expended on this insect. Recommended controls were effective in limited, replicated trials. Careful observation and thorough spraying with recommended pesticides (3), when needed, provide effective control of this insect.

Grape Leafhopper

Grape leafhoppers appear early in the season on bunch grape and remain there throughout the leaf season. Adult insects are about 1/8 inch long, and pale yellow, marked with bright red. Eggs are laid in the leaf tissue and adults and their pale yellow offspring feed on the undersides of the leaves. Nymphs are usually aligned on leaf veins. Feeding results in white or chlorotic leaf spots observable from above, and extensive feeding may result in leaf drop and reduced plant vigor. Fecal accumulations on grape bunches are unsightly and support growths of sooty mold.

In 1974 and 1976 tests of insecticides to control leafhoppers, acephate and dimethoate were as effective as carbaryl and more effective than leptophos and methomyl. Acephate was also more effective than permethrin and fenvalerate. In 1980 and 1981 experiments acephate was applied once at various rates and compared with methio-

Table 1. Infestation rate by grape seed chalcids of 'Blue Lake' berries exposed at weekly intervals from April 17 to June 12.

	Wasps emerged/berries exposed for week ending								
	April		May					June	
Vine[z]	17	24	1	8	15	22	29	5	12
1	0/99	0/128	30/162	13/139	14/117	0/148	0/132	0/97	0/108
2	0/149	0/53	9/354	40/134	46/181	22/248	0/177	1/144	0/105
Total	0/248	0/181	39/516	53/273	60/298	22/396	0/309	1/241	0/213
Rate/100 berries			8	19	20	5		0.5	

[z]Four bunches/vine uncovered each week.

carb or carbaryl. Insecticides were applied with a backpack mistblower (Solo Jr., Model 410). Evaluations were made by counting leafhoppers at weekly intervals on 10 leaves per plot replicated 6 times. All three materials reduced leafhopper populations immediately, but the residual effect of acephate was sustained for over 1 month (Tables 2 and 3).

Grape Root Borer

Long recognized as a killer of grapevines in the southeastern United States, this insect has already become a significant threat to some plantings of bunch and muscadine vines in Florida.

Grape root borer adults are active in the late summer and fall. Eggs are laid in the vineyard on crop plants, weeds, and even on the soil. Upon hatching, young larvae bore into the soil seeking the roots of grapevines. Larvae mine the roots for nearly 2 years. Pupae develop near the soil surface and the cast skins can be observed after adults emerge. Usually as larvae enlarge they tend to work toward the crown of the plant so 90% of larvae are found within a circle about 1-ft radius around the trunk base (8). Root borers do not always kill vines, but yields may be significantly reduced by the presence of even 1 larva in the trunk base of a vine (8). Control strategies can be aimed at the exposed pupae, larvae in the roots, or adults and the young larvae before they enter the soil.

Florida work began with observations of varietal susceptibility and with chemicals applied to the soil for control of established larvae.

Varietal susceptibility observations were made by counting pupal skins at the soil surface October 8, 1979 in a replicated test of muscadine grapevines at Leesburg. In 1980, similar observations were made at Leesburg and in a commercial planting near Kathleen from September 11 to November 5.

Observations summarized in Table 4 indicate that many varieties of bunch and muscadine grapevines are affected. In 1980, at Kathleen, root borer pupal cases were found at the soil surface from September 17 to November 5. Peak occurrence was during the weeks ending October 3 and October 9. At Leesburg, pupal cases were found from September 11 to October 22. Peak occurrence was October 8 and 15.

Evaluations of chemicals to control larvae using drench

Table 4. Occurrence of grape root borer on grapevines in the ARC Leesburg research planting and a commercial vineyard: cast pupal skins at the soil surface.

	Pupal skins per vine		
	Laboratory[z]		Commercial[y]
	1979	1980	1980
Liberty			0.2
Stover			0.4
Blue Lake			0.4
Lake Emerald			0.8
Norris			1.2
Southland	0.0	0.5	0.6
Magnolia	0.0	0.2	0.6
Thomas	0.2	0.3	
Redgate	0.2	0.8	
Chief	0.2	0.0	
Regale	0.3	0.0	
Magoon	0.5	0.2	
Tarheel	0.7	0.3	1.4
Welder	0.8	0.0	2.6
Watergate	0.8	0.0	
Fry	0.8	0.3	2.6
Creek	0.8	0.0	
Dixie	1.2	0.3	0.4
Dearing	1.2	0.3	
Jumbo	1.3	0.0	4.0
US42-12B	2.2	0.2	
Cowart	2.2	0.0	
Noble	2.3	0.3	
Hunt	2.3	0.6	3.4
Sugargate	3.3	0.3	
Carlos	3.6	0.2	2.5
Higgins	4.0	0.0	2.7

[z]Average from 6 single-plant replications.
[y]Average from 5 to 15 plants of each variety.

Table 2. Leafhoppers/10 leaves from Lake Emerald plants treated with insecticides on June 17, 1980 at the ARC Leesburg Farm.

			Leafhoppers/10 leaves								
			Pre treatment	Post treatment[z]							
Treatment	Formulation	AI/acre	6/16	6/27	7/1	7/9	7/16	7/22	7/31	8/5	8/11
Acephate	75 SP	1.0	5.7	0.0 a	0.5 a	0.7 a	0.3 a	1.3 a	2.7	4.2 a	6.2 a
Acephate	75 SP	0.5	6.3	0.3 a	0.2 a	0.5 a	1.8 a	1.3 a	3.7	7.8 ab	14.7 ab
Acephate	75 SP	0.25	4.8	0.8 a	0.5 a	2.8 ab	2.0 a	2.0 a	4.2	13.2 bc	26.2 bc
Acephate	75 SP	0.125	6.7	0.5 a	0.7 a	2.3 ab	2.7 a	3.5 a	4.0	13.7 bc	21.2 bc
Methiocarb.	75 WP	1.0	5.8	0.0 a	2.7 a	8.5 bc	8.7 b	5.0 b	6.3	18.0 c	23.5 c
Untreated	—	—	3.5	3.0 b	12.2 b	13.5 c	15.7 c	9.2 b	7.3	19.2 c	25.7 c

[z]Mean separation in columns by Duncan's new multiple range test, 5% level.

Table 3. Leafhoppers/10 leaves from Lake Emerald plants treated with insecticides on July 15, 1981 at the ARC Leesburg research farm.

			Leafhoppers/10 leaves						
			Pre treatment	Post treatment[z]					
Treatment	Formulation	AI/acre	7/1	7/15	7/29	8/5	8/12	8/19	8/26
Acephate	75 SP	1.0	7.2	0.7 a	1.8 a	1.0 a	1.2 a	5.2 ab	2.3 a
Acephate	75 SP	0.5	7.2	0.2 a	1.2 a	0.8 a	1.0 a	2.5 a	4.5 ab
Acephate	75 SP	0.25	7.3	1.2 a	0.8 a	1.8 a	1.8 a	5.8 ab	4.8 ab
Carbaryl	50 WP	1.0	7.5	1.8 a	4.0 b	4.3 b	2.3 a	6.5 bc	6.3 b
Methiocarb	75 WP	1.0	10.7	0.3 a	3.8 b	5.5 b	5.8 b	9.5 cd	10.2 c
Untreated	—	—	7.2	12.5 b	14.5 c	11.2 c	7.0 b	12.0 d	11.3 c

[z]Mean separation in volumns by Duncan's new multiple range test, 5% level.

treatments and ethylene dichloride fumigation have been initiated.

Leafhopper Vectors of Pierce's Disease

PD is a rickettsia-like bacterium (RLB) incited disease that limits grape culture in Florida (14, 19). It has been transmitted by leafhoppers of all species of the subfamily Cicadellinae tested as vectors (18) including 2 species that breed on grapevines in Florida: *Oncometopia nigricans* (Walker) and *Homalodisca coagulata* (Say) (5). We have also used bacteria-free leafhoppers to move the RLB of PD from blight affected citrus to grapevines on which PD symptoms developed (13).

In extensive ecological studies, *O. nigricans* adults were observed on 63 hosts and nymphs on 41 hosts (4). *H. coagulata* adults were observed on 46 hosts and nymphs on 33. Host plants were both woody and herbaceous.

Epidemiological studies showed that leafhoppers, whether naturally infective from feeding on grapevines or fed on PD infected grapevines or blighted citrus in the field, first became infective between April 23 and May 23. Hopkins (12) found that bacteria build up strongly in the stems, petioles, and leaves of PD-infected Schuyler grapevines in the field between April 21 and June 7. There is excellent correlation between the occurrence of infective vectors and bacterial buildup. These events occur after leafhoppers have migrated from weeds on which they have overwintered to the grapevines and other summer hosts. We have found that leafhoppers leaving winter hosts are not naturally infective with PD.

PD bacteria were recovered from wild plants *Ampelopsis arborea* (L.) Rusby (pepper vine), Virginia creeper, and *Sambucus canadensis* (L.) (American elder) (6). Symptom expression in the plants was especially marked in Virginia creeper and American elder. In American elder the bacterium causes a significant disease.

Control of Pierce's Disease.

Tetracycline antibiotics, applied as a soil drench or foliar spray, have been somewhat effective against the bacterium that causes PD (11). However, they are more effective as protectants than as remitting agents. The level of control in susceptible grapevines has not been consistently good enough for use in commercial vineyards. Perhaps, with new application methods or with some new antibiotic, chemical control of PD may be achieved in the future.

Presently, the only effective control for PD is resistance (15). Grapes must be resistant to PD to have a productive lifespan in Florida. Most varieties of muscadine grape (*V. rotundifolia* Michx.) have a high degree of resistance, but some are susceptible. In Florida, for example, 'Pride', 'Carlos', 'Lucida', and 'Scuppernong' are examples of muscadine varieties that are susceptible to PD (15). Five PD-resistant bunch grapes have been released by the ARC, Leesburg. The resistance of these five—'Lake Emerald', 'Blue Lake', 'Norris', 'Stover', and 'Liberty'—was derived from wild species of bunch grape that thrive in the Southeastern U.S.A. (17).

The Pierce's disease bacterium may be eliminated from diseased plant tissue by hot water treatment (9). The diseased tissue is immersed in water at 45 C for 180 min., 50 C for 20 min., or 55 C for 10 min. This is mainly of value in preventing the introduction of the PD bacterium to new geographical areas in diseased cuttings.

Anthracnose Control

Anthracnose is the most serious fungal disease of bunch grape. Lesions are produced on leaves, stems, and fruit. Muscadines and 'Blue Lake' bunch grape are resistant. Since the causal organism overwinters in lesions on the dormant grapevines, application of fungicides during dormancy has been a recommended practice in Florida.

In 1977 and 1980 we evaluated dormant and bud-break applications of fungicides for early season anthracnose control. Test plots were arranged in a randomized block of 4 replications with 4-6 vines/plot. Treatments were applied with a backpack mistblower (Solo Jr., Model 410). The 3 fungicides applied after bud-break (benomyl, captafol, and captan) were most effective in reducing early season anthracnose development (Table 5). The dormant application of the high rate of liquid lime-sulfur was also very effective.

Table 5. Effect of dormant or bud-break application of fungicides on anthracnose of grapevine.

Treatment[z]	% infected canes[y] 1977	% infected canes[y] 1980	Anthracnose rating (0-10)[y] 1977	Anthracnose rating (0-10)[y] 1980
Captafol, 2.5 lbs	42 bc	2 a	2.4 ab	0.2 a
Captan, 5.0 lbs	—	3 a	—	0.2 a
Benomyl, 0.75 lb	13 a	5 ab	1.4 a	0.4 ab
Liquid lime-sulfur, 8.0 gal	25 ab	8 ab	1.8 ab	0.7 ab
Tribasic Copper Sulfate, 8.0 lbs	35 abc	20 b	2.0 ab	0.9 b
Liquid lime-sulfur, 2.5 qts	53 c	42 c	3.4 bc	1.9 c
Untreated	55 c	39 c	4.2 c	1.9 c

[z]Rates are given as the amount of active ingredient per 50 gal per acre. In 1977, treatments were applied on February 28. In 1980, captafol, captan, and benomyl were applied on March 24, and all other treatments on March 6.

[y]Anthracnose ratings were made on March 31, 1977, and April 17, 1980. Mean separation in columns by Duncan's new multiple range test, 5% level.

Fungicides must also be applied regularly throughout the season to control anthracnose. For anthracnose control, test plots were arranged in a randomized block of 4 replications with 3 vines/plot. Fungicides were applied biweekly from the first week of April to harvest using the mistblower. Approximately 150 gallons of spray/acre was used. Benomyl, captan, folpet, and maneb + zinc provided control of anthracnose (Table 6). Alternating applications or tank mixes of 2 of these fungicides appeared to be most effective.

Table 6. Fungicidal control of grapevine anthracnose.

Treatment[z]	Anthracnose rating (0-10)[y] 1978	1979	1980
Folpet, 2.0 lbs.	2.1 ab	1.2 a	—
Captan, 2.0 lbs.	1.7 a	1.7 a	—
Benomyl, 0.75 lb.	2.0 a	1.6 a	—
Maneb + zinc, 3.2 lbs.	—	1.5 a	—
Benomyl, 0.5 lb.	2.1 ab	1.8 a	5.9 cd
Maneb + zinc, 1.6 lb.	3.3 bc	—	4.4 ab
Folpet, 2.0 lbs. alt. Maneb + zinc, 1.6 lbs.	—	—	3.7 a
Folpet, 2.0 lbs. alt. Benomyl, 0.75 lb.	—	—	4.0 a
Benomyl, 0.5 lb. + Maneb + zinc, 1.2 lbs.	—	—	4.1 a
Captan, 2.0 lbs. alt. Maneb + zinc, 1.2 lbs.	—	—	4.4 ab
Benomyl, 0.75 lbs. alt. Maneb + zinc, 1.6 lbs.	—	—	5.2 bc
Unsprayed	4.2 c	3.7 b	6.5 d

[z]Rates are given as the amount of active ingredient/acre. Materials were applied biweekly and alt. means that the 2 materials were used in alternating applications.

[y]Anthracnose ratings were made on August 7, 1978, July 2, 1979, and July 31, 1980. Mean separation in columns by Duncan's new multiple range test, 5% level.

Fruit Rot Control

Black rot (*Guignardia bidwellii* [Ell.] Viola & Ravaz) attacks grape foliage and fruit, but damage to fruit is the more important. The disease appears as light brown spots and the berries soon shrivel and become dark, hard, shriveled mummies which may remain on the bunch for weeks. This fungus attacks the green berries until the beginning of ripening. In Central Florida this infection period coincides with our dry season in many years, resulting in the sporadic occurrence of severe black rot. However, preventive fungicide sprays are necessary.

Bitter rot (*Melanconium fuligineum* [Serib. & Viola] Cav.) and/or ripe rot (*Glomerella cingulata* [Ston.] Spauld. & Schrenk) are severe problems most years. They infect ripening or mature fruit. The infected berries rot and shatter easily from the cluster. Bitter rot appears to be the most serious berry rot of muscadines.

The experimental design of fruit rot control tests was similar to that described for anthracnose in the previous section. Black rot was effectively controlled by benomyl (Table 7). Bitter rot was controlled by benomyl and a high rate of maneb + zinc in 1979. In 1981, a maneb + zinc combined with folpet was most effective. All combinations that include benomyl were very effective. Yields were not significantly different. However, the rot was so severe that the unsprayed fruit was unmarketable.

Leafspot Disease Control

Several leafspot diseases on grapevines are not usually found until July or August. These include *Isariopsis* leafspot, downy mildew, and powdery mildew on bunch grapes and *Cercospora* on muscadines. These diseases must be controlled to prevent premature defoliation, thus promoting a stronger vine.

The experimental design of tests to evaluate the control of grape leafspot diseases was similar to that described above for anthracnose. Fungicide applications were biweekly and disease ratings were made the first 2 weeks of August. As with fruit rot, the leafspot phase of black rot was best controlled by benomyl, either alone or in combination (Table 8). All the fungicides provided good control of *Isariopsis*. Alternate applications of folpet or captan with maneb + zinc were most effective. Downy mildew was unusually severe in the 1980 test. Folpet alternated with maneb + zinc was best against downy mildew. All treatments containing maneb + zinc were effective. Premature defoliation in 1980 was prevented equally well by all treatments except benomyl alone. This was expected of benomyl since it is not active against downy mildew. The defoliation was caused by downy mildew, anthracnose, and *Isariopsis*.

Discussion

Except for grape root borer, recommendations for controlling insects damaging Florida grapevines are available (3). The only legal chemical control for grape root borer presently is ethylene dichloride injected into the soil under grapevines to reduce established larval infestations. Ex-

Table 7. Fungicidal control of fruit rot of grape.

Treatment[z]	% black rot	% bitter rot		Yield (lbs./vine)
	1978	1979	1981	1981
Benomyl, 0.75 lb.	10 a[y]	14 a		
Benomyl, 0.5 lb.	10 a	15 a		
Maneb + zinc, 3.2 lbs.	—	11 a		
Folpet, 2.0 lbs.	54 b	25 ab		
Captan, 2.0 lbs.	53 b	50 bc		
Maneb + zinc, 1.6 lbs.	47 b	—	25 bc	14.3
Maneb + zinc, 1.2 lbs. + Folpet, 1.5 lbs.	—	—	11 a	19.0
Benomyl, 0.5 lb. + Maneb + zinc, 1.2 lbs.	—	—	14 a	18.1
Benomyl, 0.75 lb. alt. Maneb + zinc, 1.6 lbs.	—	—	18 ab	14.3
Benomyl, 0.75 lb. alt. Folpet, 2.0 lbs.	—	—	19 ab	18.1
Benomyl, 0.5 lb. + Captan, 1.5 lbs.	—	—	20 ab	17.1
Folpet, 2.0 lbs. alt. Maneb + zinc, 1.6 lbs.	—	—	21 ab	16.5
Captan, 2.0 lbs. alt. Folpet, 2.0 lbs.	—	—	33 c	11.7
Unsprayed	54 b	60 c	70 d	11.4

[z]Rates are given as the amount of active ingredient/acre. Materials were applied biweekly and alt. means that the 2 materials were used in alternating applications.
[y]Mean separation in columns by Duncan's new multiple range test, 5% level.

Table 8. Fungicidal control of grapevine leafspot diseases.

Treatment[z]	Black rot[y]	Isariopsis[y]		Downy Mildew[y]	% defoliation[y]
	1980	1978	1980	1980	1980
Benomyl, 0.5 lb.	0.9 a[x]	0.1 a	2.1 b	5.6 cd	28 b
Maneb + zinc, 1.6 lbs.	2.4 abc	0.6 ab	1.0 ab	3.5 ab	5 a
Captan, 2.0 lbs.	—	0.8 ab	—	—	—
Folpet, 2.0 lbs.	—	1.1 b	—	—	—
Folpet, 2.0 lbs. alt. Maneb + zinc, 1.6 lbs.	2.3 abc	—	0.4 a	2.8 a	5 a
Captan, 2.0 lbs. alt. Maneb + zinc, 1.6 lbs.	2.6 bc	—	0.6 a	3.8 ab	6 a
Benomyl, 0.5 lb. + Maneb + zinc, 1.2 lbs.	1.7 ab	—	1.0 ab	4.3 abc	8 a
Benomyl, 0.75 lb. alt. Maneb + zinc, 1.6 lbs.	2.0 abc	—	1.4 ab	4.7 bc	8 a
Folpet, 2.0 lbs. alt. Benomyl, 0.75 lb.	1.9 abc		1.7 ab	4.9 bc	6 a
Unsprayed	3.4 c	2.9 c	5.4 c	7.1 d	52 c

[z]Rates are given as the amount of active ingredient/acre. Materials were applied biweekly and alt. means that the 2 materials were used in alternating applications.
[y]Disease ratings are on a 0-10 scale. Isariopsis was rated on 8/7/78 and 8/14/80. Black rot and downy mildew were rated on 7/31/80. Percentage defoliation was determined on 8/14/80.
[x]Mean separation in columns by Duncan's new multiple range test, 5% level.

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.

Literature Cited

1. Adlerz, W. C. 1972. *Prodecatoma cooki*, a seed chalcid on Florida grapes. J. Econ. Entomol. 65:1530.
2. ———————. 1973. Seed chalcid damage, distribution and control on central Florida bunch grapes. Proc. Fla. State Hort. Soc. 86: 335-338.
3. ———————. 1980. Spray program for bunch grapes. Leesburg ARC Res. Rept. WG80-4.
4. ———————. 1980. Ecological observations on two leafhoppers that transmit the Pierce's disease bacterium. Proc. Fla. State Hort. Soc. 93:115-120.
5. ——————— and D. L. Hopkins. 1979. Natural infectivity of two sharpshooter vectors of Pierce's disease of grape in Florida. J. Econ. Entomol. 72:916-919.
6. ——————— and ———————. 1981. Detection of Pierce's disease bacterium in wild plants in Florida Phytopathology 71:856 Abs.
7. Dutcher, J. D. and J. N. All. 1978. Reproductive behavior of *Vitacea polistiformis* (Harris). J. Georgia Entomol. Soc. 13:59-63.
8. ——————— and ———————. 1979. Biology and control of the grape root borer in Concord grape vineyards. Georgia Agr. Exp. Sta. Res. Bul. 232.
9. Goheen, A. C., G. Nyland, and S. K. Lowe. 1973. Association of a rickettsia-like organism with Pierce's disease of grapevines and alfalfa dwarf and heat therapy of the disease in grapevines. Phytopathology 63:341-345.
10. Hopkins, D. L. 1973. Fungicidal control of bunch grape diseases in Florida. Proc. Fla. State Hort. Soc. 86:329-333.
11. ———————. 1979. Effect of tetracycline antibiotics on Pierce's disease of grapevine in Florida. Proc. Fla. State Hort. Soc. 92:284-285.
12. ———————. 1981. Seasonal concentration of the Pierce's disease bacterium in grapevine stems, petioles, and leaf veins. Phytopathology 71:415-418.
13. ———————, W. C. Adlerz, and F. W. Bistline. 1978. Pierce's disease bacterium occurs in citrus trees affected with blight (Young tree decline). Plant Dis. Reptr. 62:442-445.
14. ——————— and H. H. Mollenhauer. 1973. Rickettsia-like bacterium associated with Pierce's disease of grapes. Science 179:298-300.
15. ———————, ———————, and J. A. Mortensen. 1974. Tolerance to Pierce's disease and the associated rickettsia-like bacterium in muscadine grape. J. Amer. Soc. Hort. Sci. 99:436-439.
16. Mortensen, J. A., W. C. Adlerz, and D. L. Hopkins. 1975. Thirty questions and answers for grape growers. Leesburg ARC Research Report—WG75-5.
17. ———————, L. H. Stover, and C. F. Balerdi. 1977. Sources of resistance to Pierce's disease in *Vitis*. J. Amer. Soc. Hort. Sci. 102: 695-697.
18. Purcell, A. H. 1979. Leafhopper vectors of xylem-borne plant pathogens. In: Leafhopper vectors and plant disease agents. Maramorosch, K. and K. F. Harris Eds., pp 603-625. Academic Press.
19. Stoner, W. N., L. H. Stover, and G. K. Parris. 1951. Field and laboratory investigations indicate grape degeneration in Florida is due to Pierce's disease virus infection. Plant Dis. Reptr. 35:341-344.

Proc. Fla. State Hort. Soc. 94:336-339. 1981.

GRAPE WEED RESEARCH AND RECOMMENDATIONS[1]

C. E. Arnold and J. H. Aldrich
University of Florida, IFAS,
Agricultural Research Center,
Monticello, FL 32344

Additional index words. herbicides, muscadine, *Vitis rotundifolia*, weed control.

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**

[1]Florida Agricultural Experiment Station Journal Series No. 3395. Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product and does not imply its approval to the exclusion of other products that may also be acceptable.