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FUNGICIDES FOR DISEASE CONTROL ON AVOCADOS, LIMES AND MANGOS IN FLORIDA

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ABSTRACT

Copper has been the most widely used fungicide for control of fungal and algal diseases of avocado, lime and mango. The carbamates (ferbam, maneb, Dithane M-45, and Manzate 200) have proven useful in the control of fungal diseases on all three crops. Over the past fifteen years other fungicides (Phaltan, thiram, Daconil 2787, Polyram, and Difolatan) have been tested with varying degrees of success.

The new fungicide benomyl has shown considerable promise as an avocado and mango fungicide in experiments during the past four years. It has been especially effective on mango and avocado anthracnose, avocado scab, and powdery mildew of mango.

No single fungicide has been found which provides good control of all the fungal and algal diseases of each fruit.

INTRODUCTION

The major avocado, lime, and mango diseases cause annual loss to Florida growers. With the strict grade standards in effect control of diseases causing fruit blemishes and decay has become very important. Most avocado, lime and mango diseases are adequately controlled by various rates of some form of copper (23, 24, 15). Unfortunately disease control is never perfect (flawless) because complete coverage is a practical impossibility and because growth of leaves and fruit exposes unsprayed tissue to infection.

Copper fungicides have been used to control diseases of avocado, mango and lime for many years. Research has shown that several of the new organic fungicides are useful and even superior to copper for fruit disease control. Since the tropical fruits are considered as minor crops it has been difficult to obtain the approval of the Food and Drug Administration to use new fungicides on these fruits even though fungicide manufacturers have spent much time and money on this effort.

This is a review on the current status of research, in Florida, involving use of certain fungicides that require registration under the Federal Insecticide, Fungicide, and Rodenticide Act. It is not the intent of this review to recommend the use of such chemicals, nor does it imply that the uses discussed have been registered. All uses of these chemicals must be registered by the appropriate State and Federal agencies before they can be recommended.

The recent investigations of organic fungicides in comparison with the Bordeaux-emulsions and copper fungicides on the major avocado, lime and mango diseases are reviewed in the present paper.

AVOCADO

(*Persea Americana* Mill.)

One of the most persistent expenses to the avocado grower is disease control. Avocado diseases such as *Cercospora* spot (*Cercospora purpurea* Cke.), anthracnose (*Colletotrichum gloeosporioides* Penz.) and avocado scab (*Sphaceloma perseae* Jenkins) can cause sizable losses to Florida avocado growers.

Cercospora can infect previously uninjured fruits and leaves. Fruit infection can occur from May to September, but the most critical period is usually from May 15 to July 1 (23). In 1922 Stevens (26) first showed that *Cercospora* spot was readily controlled by timely applications of copper sprays. An application on the first of May followed by another in early June provided adequate control on mid and late season varieties,

Ruehle (23) found that 4-4-100 Bordeaux, wettable cuprous oxide 1 pound to 100 gallons of water, or other neutral copper fungicides used at about equal metallic copper content in the spray, were effective fungicides.

Anthracnose or black spot caused by the fungus *Colletotrichum gloeosporioides* Penz. is commonly found on dead twigs and in dead tissue on leaves and fruits. The fungus commonly infects fruits through wounds, such as *Cercospora* lesions. When *Cercospora* spot is adequately controlled there is usually very little problem with anthracnose. Late maturing varieties, such as 'Nabal', 'Taylor', and 'Choquette', generally require an early September application of a copper fungicide to reduce anthracnose infection on wind scarred and insect-stung fruit (23).

Avocado scab is found on young succulent tissues of avocado leaves, twigs, and fruits. Stevens (25) first showed that scab can be controlled on the fruit of susceptible varieties with properly timed sprays of 6-6-100 Bordeaux. Ruehle (21) obtained equally good control with 1%-100 wettable cuprous oxide and other neutral copper fungicides which leave less residue than Bordeaux. The most susceptible variety 'Lula' required three sprays in addition to the *Cercospora* spray program. Ruehle's recommendation was that the first spray should be applied just as the bloom buds begin to open, usually late in January; the second spray is applied near the end of the main bloom period, when many small fruits have set, usually from the middle of February to March 1; the third spray follows, three to four weeks later after all the fruit has set (23).

Euehle and Cono ver (25) reported that copper and ferbam were equally effective in controlling avocado scab on 'Lula' avocado. They also reported that Phaltan, thiram, captan, and dodine showed some promise for scab control Phaltan and captan were toxic. McMillan (18) found that a new surfactant Nu Film 17 in combination with Kocide 101 (eupric hydroxide) and Tribasic copper sulfate enhanced scab control. Kocide 101 plus Triton B 1956 provided a higher percentage of scab free fruit and a lower percentage of severe scab fruit than Tribasic copper sulfate plus Triton B-1956.

Benomyl, a new systemic fungicide, gave better control of scab than any of the forms of copper, when used at the rate of 8 ozs per 100 gallons on a monthly schedule (19) ; Difolatan, although not [equal to benomyl, was superior to copper. I Stem-end rot caused by *Diplodia natalensis* Pole-Evans and/or *Diaporthe citri* Wolf result in occasional post-harvest shipping or storage problems, particularly on immature fruit. No additional new or test fungicides other than the copper sprays for *Cercospora*, Scab, and anthracnose are effective for stem-end rot control. Mature fruit packed in well ventilated containers and kept refrigerated within safe limits have little problem with stem-end rot (23).

Powdery mildew (*Oidium* sp.) frequently occurs on the foliage of unsprayed avocado trees. Ruehle (23) reported that powdery mildew was never of sufficient importance to justify the expense of special sprays for its control in commercial groves which were sprayed regularly for control of other fruit diseases.

LIME

Citrus latifolia Tanaka

Limes are generally grown in the coastal areas of southern Florida. The climatic conditions in this area, such as high humidity presents the lime grower with a continual expensive battle in controlling diseases. The most important diseases, are melanose (*Diaporthe citri* (Fawc.) Wolf), scab (Blasioe fawcetti Bitancourt & Jenkins), greasy spot, (*Cercospora citri-grisea* sp. nov.), and red alga (*Cephaleuros virescens* Kenze). These diseases singly or together cause serious problems for the Florida lime grower.

Melanose attacks the immature foliage, twigs and fruits. Burger, De Busk, and Briggs (1) recommended a single application of Bordeaux-oil emulsion 3-3-50 plus 1 per cent of oil, 10 to 20 days after two-thirds of the bloom has dropped. That same year Winston and Bowman (30) suggested two applications, the first application, April 1 to 10, second application, May 1 to 10. In 1931 Rhoads and De Busk (20) found that one application of a Bordeaux-oil emulsion, 6 pounds of copper sulfate, 6 pounds of lime with 1 per cent of oil, between April 15 and May 5 was effective. The best results were obtained by spraying in April just after fruit set. At present a single copper spray containing 3.75 pounds of copper (metallic) per 500 gallons applied 1 to 3 weeks after petal-fall provides good control. In groves where melanose has been persistent for several years, or during very wet springs, or when there is late or scattered bloom, a second application 4 weeks later enhances disease control (13). Pruning dead wood from old trees is an important measure in the control of melanose since this is the principal source of infection.

Scab attacks the immature tissues of new leaves, twigs, and fruits of many kinds of citrus. Tahiti lime shows marked resistance compared to other citrus. However, scab can present problems in lime groves located near abandoned citrus plantings. Early researchers, Fawcett (3), Grossenbacher (14), and Winston (29) found that the copper sprays, such as Bordeaux mixture, were the most effective. Rhoads and De Busk (20) reported that two applications of Bordeaux-oil emulsion, 6-6-100 plus 1 per cent oil, should be applied when disease conditions were severe, the first just before growth starts in the spring and the second after two-thirds of the blossoms have fallen. In 1965

Fisher (10) reported that two applications of 1.5 to 2 pounds of ferbam followed by copper sulfate in 100 gallons of water at two-thirds petal fall gave better scab control than two applications of copper. Also, two applications of ferbam at 1.0 to 1.5 pounds alone and 1.0 to 1.5 pounds of ferbam in combination with triphenyltin hydroxide (TPTH) at 0.5 to 0.25 pounds per 100 gallons were very effective in scab control. The Florida Citrus Spray and Dust Schedule for 1971 recommends two sprays of ferbam at 7.5 pounds, 76 WP, per 500 gallons or copper for scab control, the first spray to be applied just before trees begin to flush and the second when two-thirds of the petals have fallen (13). Fisher (9) reported that, under conditions of high humidity, ferbam at 1.5 pounds per 100 gallons gave better scab control than other chemicals when applied at pre-bloom and two-thirds petal fall.

Greasy spot develops after leaf and stem tissues have matured. Lesions occasionally form on the fruit of Tahiti lime. Fawcett (4) reported that Japanese citrus growers were of the opinion that one application of Bordeaux mixture in June, after flush, reduced the disease. Fisher (5) found that four applications May 2, June 23, August 3, and November 17 of 3 pounds of neutral copper per 100 gallons combined with oil provided good control. Timing of sprays was significant. A single application in July gave better control than an application made in August. Thompson, et al. (27) reported that a neutral copper, equivalent to 0.5 pound of metallic copper per 100 gallons, gave the most consistent control but oil emulsions were also effective and in some tests equal to copper. Timing of copper applications was involved with control. All July sprays were effective. June and August applications were effective in one grove and not in another; none of the September applications were effective. In 1956 Fisher (6) reported that the most practical program for greasy spot control included a summer oil-emulsion spray. Copper sprays gave good control but reduced fruit grade by intensifying and blackening the lesions already present on the fruit. Thompson, et al. (28) found that greasy spot was reduced with a July or August application of 0.4 pound of metallic copper per 100 gallons; however, two applications, one in July at 0.27 pound and a second in August at 0.16 pound, were more effective. A July oil emulsion application was as effective in Central Florida as one copper spray, but was not effective on the East Coast. They also reported effective treatments of either oil in July followed in August with 0.27 pound of copper or copper in June followed with oil in July. Other effective fungicides were two applications of Captan at 2 pounds or Ziram at 1 pound per 100 gallons. Fisher (7) also reported that oil emulsion, copper, or zineb in various combinations applied from mid-June to early August gave satisfactory control of greasy spot.

Stylar-end break down disease of Tahiti lime is restricted to the fruit. No causal organism has been associated with this disease and it is generally classified as a physiological disorder. Fisher (8) reported that trees sprayed with one and a half pounds per 100 gallons of ferbam alone or in combination with $\frac{1}{2}$ pound of triphenyltin hydroxide had less stylar-end break down than those sprayed with 2 pounds of tribasic copper.

The Florida Citrus Spray and Dust Schedule for 1971 recommends a copper spray on the spring flush for greasy spot and scab control, followed by application of 5 pounds of zineb or 1.25 to 2.50 pounds of copper (metallic) to 500 gallons, except in the Indian River area where zineb is ineffective. Oil at 1.0% of FC 435-66 with or without the

addition of zineb may be applied in July (13).

Red alga frequently causes severe damage to leaves, twigs and small branches of Tahiti lime. Copper sprays generally control algal disease. The control program suggested by Knorr, et al. (15) includes pruning the diseased and dead limbs as well as spraying the trees with Bordeaux mixture or a neutral copper. Fisher and McMillan (11) observed that Daconil, 1.5 lb per 100 gallons, applied at petal fall was more effective than basic copper sulfate, 0.75 lb. per 100 gallon but these results of one seasons work warrant further study.

MANGO

(*Mangifera indica* L)

For most of the commercial mango varieties anthracnose is probably the most difficult production problem facing the mango grower. Copper in any one of its many forms is of limited value for anthracnose control. Ruehle and Ledin (24) found that weekly applications of zineb, maneb or captan during bloom followed by monthly applications of copper after fruit set provided anthracnose control. Maneb alternated with zineb and Dithane M45 followed with tribasic copper or Dithane M45 used in bloom as well as post bloom provided good control of anthracnose. However, fruit decay after harvest indicated that Dithane M45 was not as effective as copper in controlling latent anthracnose (2). In a later experiment Conover (2) found that Daconil and Fermate alone were equal to maneb alternated with zineb as bloom sprays followed by copper in post bloom. Fermate and Copper were equally effective in post bloom but Daconil was less effective.

Benomyl has shown much promise for anthracnose control in recent studies. Field tests by McMillan (17) showed benomyl at 8 ozs. per 100 gallons was superior to 1.5 pounds of maneb per 100 gallons in bloom followed by 3.0 pounds of copper per 100 gallon in post bloom. In addition yields from benomyl-sprayed trees were increased significantly.

Powdery mildew is considered to be a minor disease on mango in Florida. However, when optimum conditions for this pathogen prevail during flowering, yield reductions can be serious in commercial groves. Powdery mildew has been reported to be controlled by copper fungicides or by sulfur sprays or dusts (16). Recently McMillan (17) found that benomyl at 8 ozs. per 100 gallons provided outstanding control of powdery mildew.

DISCUSSION

The fruit diseases that are of major importance in Florida are not only different from those of the other areas of the U.S. but they are more numerous. Florida's high relative humidity coupled with high temperatures is conducive to severe disease outbreaks. There is no doubt about the need for disease control. Diseases must be controlled if tropical fruits of marketable quality are to be produced, even on the most resistant varieties. As noted throughout the literature copper in one of its various forms is widely used for disease control (2, 13, 22, 23). Many avocado, lime, and mango groves are sprayed from one to ten times or more with copper during a fruiting season. These

fungicidal programs have resulted in a gradual build-up of copper residues in the soil, which reach levels toxic to the trees (12). Ruehle and Conover (25) recognized this potential problem in 1962 in reporting on experiments to find a substitute for copper. Ferbam was found to be as effective as copper for control of avocado scab and sour orange scab (9, 10, 15, 21). Ferbam has FDA approval but is seldom used because of skin irritation to the applicator. Many other organic fungicides evaluated to date have been either ineffective or toxic to the plant. Diodine, captan and Phaltan were found to be toxic to the foliage of avocado and triphenyltin hydroxide was toxic to citrus fruit (10, 25).

The most outstanding feature of recent fungicide research is the discovery that benomyl gives complete control of many of the diseases of avocado and mango (17, 19). Studies have been initiated on lime diseases and their possible control with benomyl. Benomyl appears to have systemic activity and acts in a therapeutic manner against established infections. Benomyl has not been cleared for use on avocado, lime and mango but this is expected in the near future.

Two decades ago, prospects for the effective control of fruit tree diseases were very poor. Developments of modern fungicides have changed this dismal outlook, and losses due to fruit diseases will probably be minimal in the future if correct procedures are followed.

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