PREHARVEST DISEASES OF CITRUS IN FLORIDA

L. W. TIMMER
University of Florida, IFAS
Citrus Research and Education Center
Lake Alfred, Florida 33850

Fruit and foliage diseases caused by fungi produce significant losses to the citrus industry in Florida's humid climate (Table 1). Losses from some diseases are due to reduced yields whereas in other cases losses are due to reduction in the external quality of the fruit. Thus, programs to control these diseases, depend greatly on whether the fruit is destined for fresh or processing markets.

Greasy spot is widespread and affects all varieties of citrus grown causing premature defoliation with subsequent yield loss as well as a fruit blemish, greasy spot rind blotch. Postbloom fruit drop is a localized problem but results in serious yield loss in years with high rainfall during the bloom period. Melanose which is most serious on grapefruit and scab which affects grapefruit, Temples, Murcotts, and some other tangerines and tangelos cause superficial rind blemishes that can greatly reduce the value of the fruit for fresh market. Alternaria brown spot affects primarily Minneola tangelos, Murcotts and Dancy tangerines, where it produces defoliation, fruit drop, and rind blemishes. Phytophthora brown rot can affect most varieties and occasionally causes large fruit losses both before harvest and in the packinghouse.

Thus, on processing fruit, growers need only be concerned with greasy spot, postbloom fruit drop, and Phytophthora brown rot and disease management is usually straightforward. On the other hand, some varieties such as Minneola tangelos and Murcotts are susceptible to all of the diseases and considerable skill is needed to produce large crops of high quality fruit.

Greasy Spot

Symptomatology and Disease Cycle. This disease appears as yellow to dark brown lesions which occur first on the underside of mature leaves of citrus trees. As lesions develop, they become darker and then become apparent as chlorotic spots on the upper leaf surface. Affected leaves abscise prematurely and tree vigor and yield are reduced. Stomata on fruit may become infected producing small necrotic spots which retain the surrounding green color. This disease is known as greasy spot rind blotch.

Grapefruit, tangelos, and lemons are the most severely affected; but, almost all commercial varieties are attacked to some extent. Early oranges are generally more susceptible than late oranges. The rind blotch is primarily a problem of grapefruit intended for fresh market use.

The disease is caused by Mycosphaerella citri. Ascospores of the fungus are produced in decaying leaf litter on the orchard floor with the major spore release occurring from May to July in Florida. Ascospores are airborne and are deposited on the underside of leaves where they germinate. During warm, humid nights in the summer, mycelium of the fungus grows epiphytically on the

Table 1. Relative importance of fungal diseases on processing and fresh market fruit of different commercial varieties.

Variety	Postbloom fruit drop (L)	Greasy spot		Phytophthora brown rot (L)	Melanose	Scab	Alternaria
		Foliage	Fruit				
Fresh fruit							
Oranges							
Early + Mid Season	+	+++	+	+++	++		
Navels	+++	+++	+	+++	++		
Valencia	++	++	+	+	++		
Grapefruit	+	+++	+++	++	++	++	
Tangerines & Hybrids							
Sunburst, Fallglo, Robinson	+	++	+	+	++	—	—
Murcotts, Minneola, Orlando	++	+++	++	+	++	+++	+++
Temple	+	++	+	+	++	+++	
Dancy	+	++	+	+	++		+++
Processing							
Oranges							
Early + Mid-season	+	+++		+++	—	—	—
Valencia	++	++		+			
Grapefruit	+	+++	—	++	—	—	—

+++ = serious economic problem; ++ = problem less severe, but fungicide applications needed for control; + = disease occurs but seldom requires treatment; — = variety immune or highly resistant; L = usually local in occurrence.

underside of the leaves. At this stage, the fungus may produce conidia of the Stenella imperfect stage; but these spores do not play an important role in disease development. After extensive epiphytic growth has occurred, the fungus penetrates the leaves through stomata. The fungus grows slowly in the leaf mesophyll for several months, but symptoms do not generally appear until about December. Leaf drop usually occurs in late winter and early spring. The fungus then invades the dead leaf and produces perithecia and ascospores again to complete the cycle.

Disease Management. This disease is usually adequately controlled by a single fungicide application in midsummer or at most 2 sprays during the summer. Sprays are timed primarily to reduce infection and symptoms on the spring and early summer flushes of growth.

Citrus spray oil alone provides adequate control on tolerant varieties, such as Valencia orange, or on other varieties when disease pressure is not intense. Oil is not fungicidal but hinders and delays symptom development and defoliation. On highly susceptible varieties such as grapefruit, or where disease pressure is heavy, a copper fungicide or a copper + oil spray is needed for adequate control. Also, copper must be used to control the rind blotch phase of the disease since oil is not effective. Applications for rind blotch control are most effective when applied in late July or August.

Warm winter temperatures enhance disease development and speed defoliation. Thus, greasy spot is more severe in south Florida and the Caribbean area than where cooler temperatures prevail. Addition of copper to summer oil sprays may be necessary more frequently in warmer areas.

Melanose

Symptomatology and the Disease Cycle. Melanose appears as raised, brick-red lesions on the fruit, stems, and leaves of citrus. When infection occurs early, lesions are more raised and, if severe, may coalesce to form mudcake melanose. Conidia are distributed in water and often produce lesions in a tearstain pattern on the fruit. Late infection generally produces flatter, brown-colored lesions.

Melanose is primarily a cosmetic disease and would not affect yield except when severe attacks occur when fruit is young. It is primarily a problem on fresh market grapefruit but can affect oranges, tangerines, and lemons as well as most other citrus.

The disease is caused by Diaporthe citri. The fungus produces airborne ascospores which serve for long-distance dispersal but play a minor role in producing symptoms. The fungus invades senescent or recently killed twigs where it produces pycnidia of the Phomopsis imperfect stage. Conidia ooze from the pycnidia during rainy weather and are washed onto susceptible fruit and leaves where they infect producing the characteristic symptoms. No spores of the fungus are produced on symptomatic tissue on living fruit, leaves, or twigs. It is only after the twigs die that the fungus reproduces. Fruit are usually susceptible until late June or early July.

Disease Management. Except in extreme cases, such as after freezes, melanose control is not necessary on fruit intended for processing. For fresh market fruit, a single application of a copper fungicide about late April or early May is often sufficient to control the disease on oranges, tangerines, and hybrids. However, coppers are protectant fungicides only and rapidly lose their

protective capacity as fruit expands. On grapefruit, additional sprays in late May or early June may be required to protect fruit. Often frequent sprays (every 2-3 weeks) of low rates of copper fungicides (1½-2 lb of metallic copper) provide the best control.

Scab

Symptomatology and the Disease Cycle. The disease begins as light, peach-colored lesions on young leaves or fruit. These develop into well-defined, warty protrusions on the surface of the fruit which usually develop a light gray color. On leaves, the protuberances often have an indentation on the opposite side of the leaf. Severely affected leaves and fruit may be seriously deformed.

Scab is a problem primarily on fresh market fruit of Temples, Murcotts, and some other tangerine hybrids and as well as on grapefruit and lemons. It may also damage rootstock seedlings of rough lemon, Rangpur lime, sour orange, and Carrizo citrange among others. Two pathotypes of the scab fungus exist in Florida, one of which attacks all of the above-mentioned varieties as well as sweet orange fruit. However, scab seldom occurs on oranges under field conditions in Florida. The second biotype does not attack sweet oranges, Temples, sour oranges, but does affect the other varieties mentioned.

Scab is caused by Elsinoe fawcettii which has a Sphaceloma imperfect stage. The sexual stage is rarely found and plays no role in the epidemiology of the disease. Conidia are produced on acervuli on the surface of lesions on leaves and fruit. Large numbers of spores are produced after only a 1-2 hours of wetting of the lesion surfaces. These conidia are splash-dispersed to young, susceptible tissue and can infect in as little as 2 to 3 hr at optimum temperature. Spore germination and infection can occur from 12 to 32°C and thus scab infection can occur at almost any time of the year in Florida. Only very young tissues are susceptible to infection; little infection occurs on leaves after they are 1/4 to 1/3 expanded, but fruit may remain susceptible for up to 2 months after bloom.

Disease Management. Benlate may be used for control of scab where resistance to the fungicide has not yet developed. Where sensitive isolates occur, this fungicide is highly effective. One spray should be applied at 2/3 petal fall which reduces inoculum production from pustules on young leaves and protects recently set fruit. A copper fungicide should be applied in late April or early May to protect developing fruit. Carbamate may be used in the petal fall spray where resistance to Benlate has developed.

Copper fungicides are not highly effective for scab control. Two applications, one at petal fall and a second 2 to 3 weeks later, will provide some control. More applications may be needed where a high degree of control is desired or in rainy years. No control is usually needed for processing fruit except occasionally on Temples which are highly susceptible.

Alternaria Brown Spot

Symptomatology and the Disease Cycle. This disease appears on the fruit as dark brown to black necrotic spots on the fruit. Lesions vary in size and, as they age, the central portion may slough

leaving pock marks on the fruit surface. On leaves, the disease appears as black necrotic spots which may follow the leaf veins or, at times, lose the centers becoming shot holes. When the disease is severe, entire leaves and shoots may be blackened and necrotic. Young stems are also infected producing similar lesions.

Dancy tangerines, Minneola tangelos and Murcotts are the varieties that are most seriously affected by the disease in Florida.

The disease is caused by Alternaria alternata pv. citri. Large, dark-walled, multi-celled conidia are produced on the surface of diseased tissue. Spores are airborne but require moisture for germination and infection. Symptoms may develop in 2 to 3 days when temperatures are above 80 F. Leaf tissue is susceptible until it is fully expanded and fruit is susceptible for at least 3 months after bloom. The fungus persists from one season to the next on twig and leaf lesions on living stems and leaves.

Disease Management. Copper fungicides are the only material registered for control of this disease, but they are not highly effective. Rovral is available under an experimental use permit. Three applications of either copper or Rovral, one in April, May, and June, are recommended for control of this disease. In rainy years, more frequent applications may be needed for disease control. The most effective program for control is applications of Rovral at first flush and petal fall followed by frequent (every 10-14 days) sprays of low rates of copper fungicides (1-2 lb of metallic copper/acre).

Postbloom Fruit Drop

Symptomatology and the Disease Cycle. This disease attacks the citrus flowers producing peach to orange-colored necrotic spots on the petals. Under severe conditions, entire flowers or clusters may be blasted by the disease. Subsequently, the fruitlet drops leaving the peduncle (button) which persists for as long as the twig remains alive. The nectaries on the button enlarge and leaves around the flower cluster may be twisted with large veins. The primary effect of the disease is reduced fruit set and yield.

The causal fungus can infect petals of nearly all varieties of citrus. However, the disease has occurred most commonly on varieties which produce cluster bloom such as Navel oranges.

The disease is caused by the fungus Colletotrichum acutatum. Abundant conidia are produced in acervuli on diseased petals. These spores are rain-splash dispersed to healthy bloom where they infect producing symptoms in 3 to 4 days. Disease severity is very closely related to the amount of rainfall which occurs during the bloom period. The fungus apparently survives for some long periods as resistant structures called appressoria on the surface of leaves. The disease is most severe on varieties such as limes which may bloom throughout much of the year. Orchards with declining or young trees which produce off-season bloom tend to be more severely affected.

Disease Management. Benlate is the only fungicide registered for control of postbloom fruit drop. However, carbamate is somewhat effective and can be applied as a tank mix to reduce the development of Benlate resistance by the fungus. The need for fungicide applications as well as the

proper timing can be determined using a predictive model. The model is based on the number of infected flowers on 20 trees and the rainfall total for the last five days. Applications are made during the bloom period whenever the model predicts more than 20% infection. From one to three sprays may be needed during the bloom depending on the amount of rainfall.

Phytophthora Brown Rot

Symptomatology and Disease Cycle. Brown rot affects fruit of all types of citrus. Lesions begin as a light brown discoloration of the fruit surface. Rotted areas remain firm even if the entire fruit becomes infected. Under humid conditions the fruit may become covered with the white mycelium of the fungus. Fruit near the soil are always the first to show symptoms even though the disease may spread through the entire tree eventually.

Brown rot is caused by three species of Phytophthora in Florida - P. nicotianae (= P. parasita), P. citrophthora, and P. palmivora. P. nicotianae is a high temperature species, but does not sporulate well on fruit and the sporangia are not deciduous. Brown rot due to this species occurs occasionally in late summer, but usually affects only affects fruit near the soil surface. P. citrophthora is a lower temperature species, but sporulates well in fruit and has deciduous sporangia. It can cause winter brown rot outbreaks and is capable of spreading throughout the tree. The most common cause of brown rot in Florida currently is P. palmivora. This is a high temperature species which sporulates well on fruit and has deciduous sporangia. If conditions are favorable in late summer, the disease becomes epidemic and can be extremely destructive.

Disease Management. Most brown rot outbreaks occur from mid-August to mid-October. In groves with a history of the disease, a single application of Aliette or a copper fungicide will provide control of the disease. In especially rainy years, a second application of a copper fungicide may be needed in mid-September.

Control Programs for Different Varieties

In spite of the many fungal diseases that affect Florida citrus, control programs for fruit destined for processing are relatively simple. On the majority of the acreage one or two applications of spray oil or a copper fungicide plus oil for greasy spot control in the summer will suffice. In some groves in some years, applications of Benlate are needed for control of postbloom fruit drop during flowering. An August application of Aliette or a copper fungicide may be needed where brown rot is a problem. Melanose and scab cause only superficial blemishes and need not be controlled on processing fruit and Alternaria does not affect varieties used for processing.

Even on some varieties for the fresh market, control programs needed to produce high quality fruit are not complex. On oranges and on tangerines that are resistant to scab and Alternaria such as Sunburst, Fallglo and Robinson, melanose is the only disease that needs to be considered in addition to those controlled on processing fruit. These varieties are not highly susceptible to melanose. Usually one to three applications of copper fungicide will provide adequate control even on older trees with abundant dead wood.

Achieving high quality fruit and good packouts of fresh market grapefruit is more problematic. Scab is now a problem in many groves and grapefruit is very susceptible to melanose. In addition, greasy spot rind blotch can be serious in some locations and an additional spray may be needed for control. Where all of these diseases are present in the same grove, 6-8 applications are commonly made for disease control only.

For tangerines and hybrids that are susceptible to scab and/or Alternaria such as Minneola and Orlando tangelos, Dancy tangerines and Murcotts, producing blemish-free fruit is very difficult. Groves heavily infested with Alternaria may need to be sprayed every 10-14 days from first flush to mid-July when the fruit become resistant. Even then, control may not be acceptable and some growers have removed these varieties when control became uneconomical.

The loss of Difolatan which had high residual activity and the ability to redistribute with rainfall has caused many problems. Benlate, the only systemic registered on citrus, has been lost for many uses due to the development of resistance by fungal pathogens. Currently, more applications of protectant materials are needed for adequate disease control than previously. Fortunately, the copper fungicides sold currently have been greatly improved and can be used at much lower rates than were needed previously. Improvements in spray equipment have also greatly reduced the spray volumes needed for disease control. Thus, the cost per application is much less than in years past. Overall, despite more disease problems, fewer fungicides available and higher standards of fruit quality, growers in most years manage to effectively control blemish problems. Effective control, however, requires closer monitoring of groves and environmental factors and greater ingenuity in designing spray programs.

Selected References

1 Knapp, J. L. (ed.) 1997. Florida Citrus Pest Management Guide. Univ. Florida, Inst. Food & Agric. Sci. Publ. SP-43. 75 pp.

2. Timmer, L. W., J. P. Agostini, S. E. Zitko, and M. Zulfigar. 1994. Postbloom fruit drop an increasingly prevalent disease of citrus in the Americas. Plant Dis. 78:329-334.

3. Timmer, L. W. and J. E. Fucik. 1976. The relationship of rainfall distribution, fruit growth, and fungicide application to the incidence of melanose on grapefruit in Texas. Plant Dis. Rep. 60:565-568.

4. Timmer, L. W., M. Priest, P. Broadbent, and M. K. Tan. 1996. Morphological and pathological characterization of species of Elsinoe causing scab diseases of citrus. Phytopathology. 86:1032-1038.

5. Whiteside, J. W. 1970. Etiology and epidemiology of citrus greasy spot. Phytopathology 60:1409-1414.

6. Whiteside, J. O. 1976. A newly recorded alternaria-induced brown spot disease on Dancy tangerines in Florida. Plant Dis. Rep. 60:326-329.

7. Whiteside, J. O. 1977. Sites of action of fungicides in the control of citrus melanose. Phytopathology 67:1067-1072.

8. Whiteside, J. O. 1978. Pathogenicity of two biotypes of Elsinoe fawcettii to sweet orange and some other citrus cultivars. Phytopathology 68:1128-1131.

9. Whiteside, J. O. 1979. Alternaria brown spot of Dancy tangerines and its control. Proc. Fla. State Hort. Soc. 92:34-37.

10. Whiteside, J. O. 1982. Timing of single-spray treatments for optimal control of greasy spot on grapefruit leaves and fruit. Plant Dis. 66:687-690.

11 Whiteside, J. O., S. M. Garnsey, and L. W. Timmer (eds.). 1988. Compendium of Citrus Diseases. APS Press, St. Paul, MN. 80 pp.