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AN UPDATE ON POSTBLOOM FRUIT DROP IN THE INDIAN RIVER AREA AND RESULTS OF A FUNGICIDE TEST ON THE DISEASE

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Abstract. **Observations on the incidence of postbloom fruit drop (PFD) in 3 navel orange groves in the Indian River area from 1988 to 1993 are presented. The extent and severity of PFD in the Indian River area in 1993 is discussed. A combination of benomyl and ferbam applied in a commercial grove was more effective than benomyl alone in reducing blossom infection.**

Postbloom fruit drop (PFD) of citrus caused by *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc. in Penz. was first noticed in the southern portion of the Indian River citrus-growing area, in Martin county, in the spring of 1987. The disease was first reported in Florida, in southwest Florida, in 1984 (McMillan and Timmer, 1988). By the spring of 1988, the disease was observed in groves throughout Martin, St. Lucie and Indian River counties in an area encompassing over 90% of the citrus in the area. A severe outbreak of PFD occurred in the spring of 1993. Plantings of navel orange and to a lesser extent, Valencia orange, were the most often affected by the disease. No variety was unaffected. Incidence of postbloom fruit drop in several groves in Indian River county was monitored from spring 1988 through summer 1993 and a summary of the observations is presented. A summary of the spring 1993 PFD outbreak is also presented.

Initially, information developed in Belize, Central America by Fagan (1984) was used as a basis for fungicide applications in the Indian River area. Fagan had determined that of the compounds available in 1972, benomyl and captafol (Difolatan) were the most promising. The combination of benomyl and captafol appeared to be more effective than either alone. Captafol has since become unavailable. Timmer, more recently, (Timmer and Zitko, 1992) has found that benomyl can be effective under Florida commercial grove conditions. However, several applications may be required, especially when bloom periods are long. There is also a risk that continuous use of benomyl will result in the development of benomyl resistance, as in the case of benomyl resistance in the greasy spot and scab diseases of citrus in Florida. No other fungicides, effective against PFD are yet available. Sonoda et al. (In press) found in a small-scale field test that a greater reduction in the blossom blight phase of PFD resulted when ferbam was combined with benomyl. The use of combinations of fungicides, in addition to being more effective against a disease, may prolong the use of a fungicide when there is a risk of resistance development. Larger scale field testing of the combination of benomyl and ferbam was conducted in the spring of 1993 and the result of one of the studies is reported here.

Postbloom Fruit Drop in the Indian River Area From 1988 to the Present

Bloom 1988

PFD was severe in several plantings of navel oranges in the spring of 1988 and it was present on other citrus varieties in many groves in Martin, St. Lucie and Indian River counties. In the spring of 1988, 3 navel orange groves in Indian River county, severely affected by PFD, were selected to determine the effect 'buttons' (persistent calyces

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resulting from infection of blossoms) had on subsequent flowering and fruit set. These groves were assigned numbers 1, 2 and 3 and described in a previous publication (Futch et al., 1989). Buttons were removed from some trees and left on other trees. There was no difference in subsequent bloom and fruit set between trees with buttons removed and those in which buttons were not removed (Futch et al., 1989). There were an estimated 2000 or more buttons per tree in the summer of 1988 in all 3 navel orange groves in which button removal trials were conducted.

Bloom 1989

A few infected petals were observed in Grove 3 on an extremely small number of blossoms occurring in late December 1988. Rainfall was normal (2.00 inches) in January 1989, lighter than normal in February (1.25 inches) and above normal in March (5.32 inches) as recorded at Miles Laboratory about 0.5 miles north of Grove 1, 3 miles north of Grove 2 and 5 miles north of Grove 3. In late January 1989, 95% of the trees in Grove 3 had at least one blossom cluster and 4% of the clusters had at least one blossom infected with PFD. Light incidence of PFD was observed in Groves 1 and 2, however no effort was made to estimate incidence.

Bloom 1990

Beginning in December 1989, portions of Groves 1, 2 & 3 were monitored for PFD by assessing PFD incidence during bloom periods and numbers of buttons present on trees following bloom periods. The area monitored in Grove 1 was 6 rows of 13 trees; Grove 2, 8 rows of 27 trees and Grove 3, 8 rows of 33 trees. There were a few scattered blossoms present in Grove 2 in December 1989 and in Grove 3 in November and December, 1989. There were no blossoms in Grove 1 in December 1989. PFD was observed in Grove 3 on 3 trees in mid-December 1989, but not in the other 2 groves. An average of 26 buttons per tree resulting from infections occurring in the spring of 1989 were present in December 1989 in Grove 2. Buttons were present in Groves 1 and 3 in December 1989, but no counts were made since low temperatures on December 22 and 23, 1989 destroyed most of the buttons remaining on trees in all 3 groves. Blossoms were frozen and some leaf drop also occurred. Subsequently, the trees in the 3 groves, as well as most citrus varieties in the area, had a concentrated bloom period in early to mid February 1990. Rainfall during the bloom period was normal in February (2.81 inches) and well below normal in March (0.77 inches). Disease incidence was slight, only a few petals with symptoms were observed during the bloom period in Grove 2 and 3, and no sign of PFD was present in Grove 1. Few growers reported seeing PFD in their groves in early 1990. No buttons were observed in Groves 1, 2 or 3 in the summer of 1990.

Bloom 1991

Rainfall during the months preceding bloom and during bloom was higher than normal in the area in February 1991 (6.81 inches), March (7.05 inches) and April (6.45 inches). There was an extended bloom period. Most of the first bloom had opened by mid February in Grove 1, 2 and 3. However, even with high rainfall coinciding with bloom in all the 3 monitored groves, no blossoms with lesions or buttons were observed in any of the trees in the monitored areas. However, in another navel orange grove (Grove 4) about 500 ft east of Grove 3, PFD lesions were observed on scattered trees at the end of March. In several Orlando tangelo blocks in St. Lucie county, with blooms occurring in late March and in April, a high incidence of PFD was observed and a high incidence of buttons were present. A high incidence of PFD was also observed on late bloom in a few St. Lucie county navel orange groves with multiple bloom periods and in groves near Indiantown in Martin county. No buttons were observed in Groves 1, 2 and 3 in the summer of 1991.

Bloom 1992

Rainfall during the 1992 bloom period was lighter than normal, February (3.42 inches), March (0.89 inches) and April (3.01 inches). No disease was observed in Groves 1, 2 and 3. No buttons were observed in Groves 1, 2 and 3 in the summer of 1992. Grove 4, on the other hand, had a high incidence of the disease in the spring and a high incidence of buttons in the summer of 1992. There were several other groves in the area that were affected by PFD, most of them with a light incidence of the disease.

Bloom 1993

Frequent rains began in late December 1992 and continued through January 1993. In January there were 16 days on which rainfall was recorded for a total of 7.30 inches. Observations for PFD was initiated on January 4. About 80% of the trees in Grove 4, which had had significant amounts of PFD in the spring of 1992, had open blossoms with PFD lesions on January 4. On some trees, dried petals with symptoms of PFD were seen on clusters that had bloomed in December 1992. In Grove 1, 11.5% of the trees had some open blossoms but none with PFD lesions on January 11. Groves 2 and 3 were not in bloom in early January.

Blossoms affected by PFD were observed at the beginning of January in several other groves in the Indian River area. Many of the trees with PFD were young trees in groves where the disease had not been reported in the past. Rainfall was normal in February (2.66 inches), much above normal in March (13.13 inches) and normal in April (1.79 inches).

By early February 1993, 36% of the trees in Grove 1 had open blooms and PFD lesions were visible in 18% of these trees. Many of the few blossoms open in early February in Grove 2 had PFD lesions. By mid-February, during a heavy bloom period, most of the trees had a high incidence of PFD. Trees in Grove 3 did not begin blooming until late January. Almost all of the trees in Grove 3 had blossoms with PFD lesions by late February.

Following the bloom period, heavy button formation was present on all trees in Groves 1, 2, 3 and 4. An estimate of fruit present on trees in the Groves 1, 2 and 3 groves was made in September, 1993 and is compared with an estimate of fruit present in the same grove in August 1989 when little or no PFD was observed in the groves (Table 1). Fruit per tree in all groves was lower than that in 1989 with Grove 2 having the least fruit per tree.

Summary of the 1993 Outbreak and Outlook of the Potential of PFD in the Indian River Area

PFD was more widespread in the Indian River area in spring 1993 than it had been in the past. Groves previously unaffected, including many young plantings, were affected. No systematic survey of losses to the disease was made in the Indian River area following the 1993 spring. However, extremely light fruit set with high incidence of buttons per tree is obvious in some navel orange groves, including Grove 1 above. Other navel orange groves were observed where substantial fruit set occurred in an early bloom which was then followed by blooms that were severely affected by PFD. Some navel orange groves that had a high incidence of PFD, as indicated by the large number of buttons in each tree, had fruit that appear to have set before PFD became severe in the grove and fruit that had set late in the spring. The disease was observed on other citrus including grapefruit, but any effect on yield was not obvious except for a few grapefruit trees near diseased navel orange trees. There were instances of groves in which infected blossoms were first observed on young reset trees, which bloomed earlier than older trees, followed by severe disease on the older, later blooming trees.

Many applications of the fungicides were necessary to protect bloom in some groves, as trees within these groves had multiple blooms with individual trees blooming at different times over an extended period. Some growers were not willing to apply the multiple sprays required. Other growers with large acreages that needed protection used ground rigs, and did not apply fungicides in time or at the right time for effective disease control. Aerial applications of fungicides which have been shown to be effective (Fagan, 1984; Timmer and Zitko, 1991) may have been more appropriate for these situations.

A relatively high level of inoculum is now scattered throughout most of the area. Because of this, there is a high likelihood of the disease occurring in spring 1994 if rain periods coincide with bloom periods. The postbloom fruit drop situation in spring 1994 may be especially severe if rainfall conditions approach that experienced in the spring of 1993. On the other hand, if rainfall in spring 1994 is light and does not coincide with major bloom periods, disease incidence can be much less than experienced in 1993. The high level of inoculum now present may be reduced if a freeze such as the December 1989 freeze occurs. Reduction in inoculum would result in less potential for disease development under similar rainfall conditions. The possibility of at least some blooms being affected by PFD will be increased if the bloom period is as extended next spring as it was in late winter-early spring 1993. However, if bloom periods are extended and rainfall occurrences are light and scattered, then trees will have more opportunity to set fruit.

Effect of Combining Benomyl and Ferbam on Disease Incidence

A test to compare the efficacy of benomyl (Benlate 50W, Methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate) alone and benomyl with ferbam (Carbamate WDG 76%, Ferric dimethyldithiocarbamate) was set up in Grove 4 which had a high incidence of disease in spring 1992. Grove 4 consisted of 51 rows of navel orange, each row with 40-41 trees, 8-12 feet high. The trees were planted in an east-west direction on double row beds except for a southmost single row. The grove was bordered on the east and west by large *Casurina* trees, on the north by a grapefruit planting and on the south by a county road. Buttons from previous year PFD were present in most trees in the grove. About 90% of the trees were in bloom and PFD lesions were visible on blossoms in most the trees when the first fungicide treatments were applied.

The experiment was set up in a split-block experimental design with time as a main block and treatment as the split plot. The treatments were 1.5 lbs Benlate 50W per acre and 1.5 lbs Benlate 50W with 6 lb Carbamate 76% per acre applied with a Rears airblast sprayer in 500 gallons of water per acre. There were 3-8-row replicates of each treatment. The fungicides were applied on January 22, February 2 and February 15, 1993. The tractor was driven between trees on beds but not in the furrows as the furrows were in poor condition and usually wet during the time when fungicides were applied.

Twenty-five to 30 clusters of just-opening blossoms in the middle 2 rows of each 8-row replicate were selected for observation and marked with plastic ribbons on the day before each fungicide application. Clusters with young fruit or very young tight blooms were not selected for observation. At the time of each fungicide application, clusters with just opening blooms were also selected for observation in the middle row of the 3 untreated rows of trees at the south end of the grove. The percent of infected petals on tagged clusters of bloom and the percent of tagged clusters with diseased blossoms were determined 3-4 days after rain periods.

Determinations of disease incidence were made on January 30, 6 days after the beginning of a 3-day rain period on clusters marked before the January 22 spray application, on February 16, 4 days after a 0.55 inch rain for clusters marked before the February 2 spray application and on February 26, 4 days after a 0.9 inch rain for clusters marked for the February 15 spray application. On April 27, 1993, fruit on tagged clusters were measured and those

Table 1. Mean number of fruit on northeast quadrant of navel orange trees in 3 groves in Indian River county, Florida in August 1989 and September 1993.

Grove	August 1989	September 1993
1	18.7	2.4
2	32.1	10.0
3	32.7	20.2

Table 2. Percent infected blossoms per cluster, percent clusters with blossoms affected by postbloom fruit drop and fruit per cluster in benomyl and benomyl plus ferbam treated trees in navel orange grove in Indian River county.

Treatment	Diseased blossoms	Blossom clusters with PFD	Fruit per cluster
	---------- % ----------		
Benomyl	8.2[z]	29.1[z]	0.64
Benomyl + ferbam	2.2	12.1	0.95

[z]Means in same column significantly different P = 0.05.

2.5 cm or larger counted. The fruit were measured so that only fruit that had set within 2 weeks after the last spray would be included as the grower applied 2 more benomyl sprays beginning 2 weeks after the last experimental spray application.

Analysis of variance (ANOVA) was performed on all measured data. Percent clusters with infected blossoms was transformed to square root arcsine prior to conducting ANOVA. Fewer open blossoms on marked clusters were affected by PFD in trees treated with the combination of benomyl and ferbam than on trees treated with benomyl alone (Table 2). Fewer of the marked clusters had diseased blossoms in trees treated with the combination of benomyl and ferbam than on trees treated with benomyl alone (Table 2). No significant difference was observed in number of fruit set on the marked clusters. On the clusters marked on the one row of untreated trees, an average of 31% of the blossoms had PFD lesions and an average of 81% of the clusters had infected blossoms. There was no fruit set on any of the marked clusters in unsprayed trees.

In this and other experiments (Sonoda et al., In press; Sonoda, unpublished), the combination of benomyl plus ferbam has been consistently more effective than benomyl alone in reducing blossom infection. However, further study is needed to determine if the increase in disease control with applications of the combination is enough to provide an increase in yield as compared to applications of benomyl only.

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AN UPDATE ON THE INCIDENCE OF POSTBLOOM FRUIT DROP ON 'TAHITI' LIMES IN SOUTH FLORIDA

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Abstract. **'Tahiti' lime Postbloom fruit drop (PFD) was first noted in Dade and Lee Counties in 1983. The symptoms of PFD in limes are small reddish-brown necrotic spots on the open petals which coalesce, with the petals becoming hard and dry and persist several days. The young fruit, 0.5 cm or less in diameter, first show a yellowish discoloration and rapidly abscise, leaving the calyxes and pedicel intact. Early studies found Benlate and Difolatan to be effective for the control of PFD. However, the registration of Difolatan was removed from the market and is no longer available to citrus growers. Recent PFD studies have shown that Carbamate, Biocide, and Tilt, alone or in combination provided disease control. 'Tahiti' lime production groves in Brazil and Mexico are reporting that PFD is seriously affecting yields.**

Postbloom fruit drop (PFD) was first noted on 'Tahiti' lime, *Citrus aurantifolia* (Christm) Sw., in Dade and Lee Counties, Florida in 1983 (McMillan and Timmer, 1989). The disease is known to occur in Argentina, Belize, Brazil, Colombia, Dominica, Panama, Venezuela, Peru, Ecuador, Guatemala, Costa Rica, El Salvador, Mexico, and Trinidad (Denham, 1988 and personal observations by the author). Until PFD occurred in Florida, most of the studies concerning this disease were conducted in Belieze. In 1971, Fagan (1971) mentioned that PFD had been observed in Florida, but there is no other documentation of those observations. The only disease similar to PFD, noted for the first time in 1960 by C. W. Campbell, TREC, Homestead, was the persistence and enlargement of the calyxes in limequat. To date, the disease occurs in limes, as well as on other citrus in Dade, Lee and other citrus growing counties in Florida (McMillan and Timmer, 1989; Timmer, 1990).

The first symptoms of PFD in 'Tahiti' limes are small reddish-brown necrotic spots on the open petals. These necrotic spots coalesce, with the petals becoming hard and dry and persist several days beyond normal petal fall for healthy flowers.

Young 'Tahiti' lime fruit, 0.5 cm or less in diameter, first show a faint yellowish discoloration and rapidly abscise, leaving the calyxes and pedicel intact. The calyx, instead of abscising may remain green for a year or more. The young diseased fruit are also distinguished by the persistence of the stigmas and styles. Profuse fungal growth is noted along the persisting styles. Dissected young fruit show a faint brownish internal discoloration at the stem end.

The fungus most consistently isolated from the petals, styles and young fruit from Dade and Lee Counties was *Colletotrichum gloeosporioides* Penz. and subsequently identified in 1988 and genetically in 1991 as a specific strain of *C. gloeosporioides* (McMillan and Timmer, 1988; Liyanage et al., 1991).

Under moist conditions the fungus produces a saucer-shaped acervulus that is lined with dark setae and short colorless stalks, on which are borne minute spores. These

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