The Control of the Sigatoka Disease of Bananas by Oil-Spray Schedules Based on Rainfall Data[1]

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INTRODUCTION

Sigatoka is the most serious disease of bananas in Puerto Rico. This leaf-spot disease attacks all the commercial varieties of bananas as well as many of the plantains. It is caused by a fungus, *Mycosphaerella musicola* Leach, (*Cercospora musae* Zimm.). The only known means of Sigatoka control is to apply an antifungal spray to the leaves.

The most commonly used materials are spray oils applied as mists at the rate of about 1 to 2 gallons per acre. In Puerto Rico the cost is about $2.00 per application per acre. In most important banana-producing regions of the world sprays are applied once every 2, 3, or 4 weeks, in about 15 to 22 applications yearly, at an annual cost of around $30 to $40 per acre. This large number of sprays is used to provide continuous protection throughout the year, because there is no widely accepted method of predicting when disease will appear on unsprayed leaves. Fewer sprays per year would probably control the disease, if a reliable forecast system were available. This could result in considerable savings for the growers.

A study was conducted recently in Puerto Rico on the relation between various climatic factors and Sigatoka (*2*).[3] The study suggested that rainfall data might provide a criterion for forecasting increases in Sigatoka incidence.

The practical usefulness of rainfall data, however, must be demonstrated in a field-spray program. Such a program, carried out at the Agricultural Experiment Substation of the University of Puerto Rico at Isabela, is described in this paper. The objective of the experiment was to determine whether a spray program based on rainfall data would require fewer sprays per year and yet maintain good disease control.

[1] A cooperative project undertaken by the Federal Experiment Station, ARS, USDA, Mayagüez, P.R., and the Agricultural Experiment Substation, University of Puerto Rico, Isabela, P.R.

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[3] Italic numbers in parenthesis refer to Literature Cited, p. 38.

MATERIALS AND METHODS

Mature clumps of banana plants of the Lacatan variety were used. This variety is highly resistant to Panama wilt, a banana disease prevalent in Puerto Rico. The clumps were spaced at 10 x 12 feet to allow sufficient room for tractor cultivation. Shallow ditches were prepared for irrigation during dry periods. Fertilizer, insecticides, and nematocides were applied periodically around the base of each plant to ensure vigorous vegetative growth.

The Lacatan plants were arranged in four long, narrow blocks isolated from each other. Each block measuring 620 x 72 feet contained 441 plants. The long axis was perpendicular to the prevailing northeasterly winds to prevent drift of oil spray from plants under one treatment to those under another. Each block was subdivided into 4 plots consisting of 12 rows of banana plants, 7 per row. Five rows of unsprayed plants were left as a buffer area between plots. A randomized, complete block design was used.

At the end of every 2 weeks, total rainfall for the previous 3-week period was determined, and the following spray schedules were carried out:

Schedule A—no spray (check); schedule B—spray every 2 weeks regardless of rainfall (check); schedule C—spray only if rainfall had attained 3 or more inches during the previous 3 weeks; schedule D—spray only if rainfall had attained 3 or more inches during the preceding 3 weeks, and exceeded the rainfall data gathered 2 weeks earlier.

The decision to spray in schedules C and D, therefore, was based directly on the rainfall data. The use of the 3-inch rainfall level per 3-week period was suggested by the earlier study cited (*2*). The spray material used was Orchard Spray Oil C,[4] one of several oils available commercially to banana growers. The undiluted oil was applied with a motorized knapsack mist-blower[5] early in the morning when there was very little or no wind. The oil mist did not drift from one plot to another. Every attempt was made to keep the spray rate within the range of 1.5 to 2.5 gallons (U.S.) per acre.

Disease incidence was observed every 9 or 10 weeks. The percentage of leaf area destroyed by Sigatoka was recorded for 3 mature leaves, *i.e.* the sixth, seventh, and eighth oldest leaves, on each of 24 plants in the center of each plot. Therefore, in the 4 replicate plots of each schedule 96 plants were under observation.

The experiment lasted from January to December 1961. During the last 4 months of 1960, all B, C, and D plots were sprayed at regular 2-week in-

[4] Mention of specific equipment or trade names is made for identification and does not imply any endorsement by the U.S. or P.R. Government.

[5] Motoblo is manufactured by the Kent Engineering and Foundry, Maidstone, England.

tervals to bring them to the same level of low disease incidence before the experiment was to begin.

RESULTS

Table 1 presents the spray and observation dates during 1961, and the rainfall for the 3-week period before the spray date. Figure 1 presents the

TABLE 1.—*Record of spray applications and observations on banana plants subjected to spray schedules based on rainfall data in inches*

Date of application or observation	Schedules used[1]	Periodical rainfall[2]
Jan. 12	B C D	3.4
Jan. 20	Observation	—
Jan. 26	B C D	4.4
Feb. 9	B C	3.6
Mar. 2	B C	3.5
Mar. 16	B C D	4.6
Mar. 23	Observation	—
Mar. 30	B C D	5.1
Apr. 13	B C	4.2
Apr. 27	B C D	13.7
May 11	B C	11.2
May 25	B C	4.3
June 1	Observation	—
June 8	B C D	5.9
June 22	B	2.5
July 6	B	2.0
July 20	B	1.8
Aug. 3	B	2.2
Aug. 10	Observation	—
Aug. 17	B	2.7
Aug. 31	B C D	5.6
Sept. 14	B C D	5.7
Sept. 28	B	2.1
Oct. 12	B C D	3.5
Oct. 19	Observation	—
Oct. 26	B C D	3.7
Nov. 9	B C D	4.4
Nov. 24	B C D	8.3
Dec. 7	B C D	9.4
Dec. 21	B C	7.7
Dec. 28	Observation	—

[1] Schedule B, spray every 2 weeks regardless of rainfall. Schedule C, spray only if rainfall attained 3 inches or more. Schedule D, spray only if rainfall attained 3 inches or more, and exceeded the rainfall data gathered 2 weeks earlier.

[2] Rainfall for the 3-week period prior to the indicated spray date. Since the spray dates are spaced 14 days apart the rainfall periods overlap by 1 week. The total annual rainfall was 78.1 inches.

average disease incidence for each of the four schedules observed six times during the year. The total number of oil-spray applications in 1961 is also shown for each schedule. Table 1 shows that during the year, 6 sprays for schedule C and 12 sprays for schedule D were omitted because of low rainfall levels.

In figure 1 the disease incidence in schedule A was significantly greater, at the 1-percent level, than that for B, C, or D, throughout the year. The

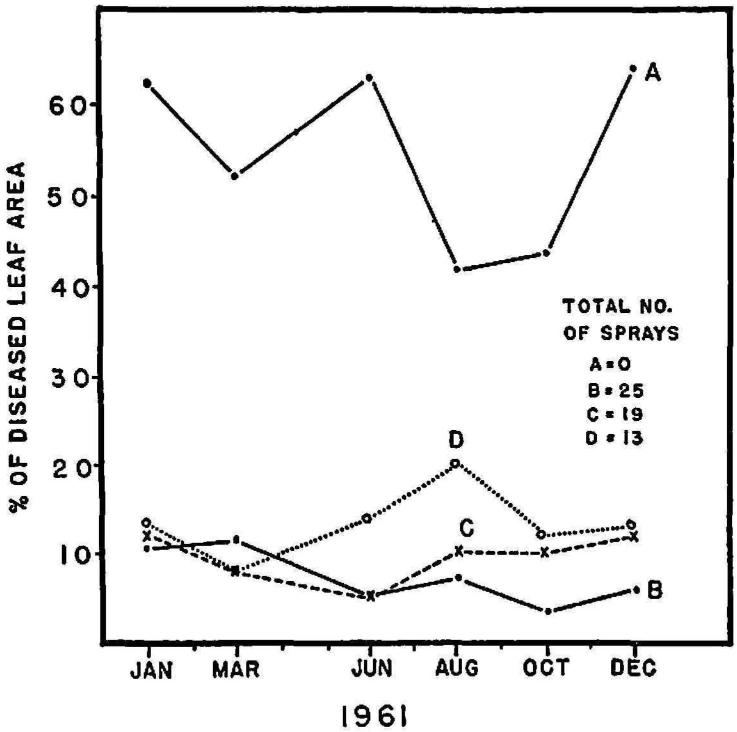

FIG. 1.—The average percentage of Sigatoka disease incidence for spray schedules based on rainfall data gathered at 2-week intervals. Schedule A—No spray (check). Schedule B—Spray every 2 weeks, regardless of rainfall. Schedule C—Spray only when rainfall attained 3 or more inches during the previous 3 weeks. Schedule D—Spray only when rainfall attained 3 or more inches during the previous 3 weeks and exceeded the rainfall data gathered 2 weeks earlier.

plants under schedule A had 42 to 64 percent of the observed leaf area destroyed by Sigatoka.

The disease levels for schedules B, C, and D, in figure 1, did not differ significantly from each other during January to March, according to statistical analysis. Between March and June curve D diverged upwards to a highly significant degree, while curves B and C showed the same low disease incidence. In August the D curve was higher than the C, which was higher than B. These differences were highly significant. From October to December a highly significant difference existed between the B curve on the one hand and the C and D curves on the other. No significant differences occurred between C and D at this time.

It is interesting to compare the number of sprays with the disease control obtained. Between the January and March observations, B and C received four applications while D received two, yet the disease level for all three schedules remained essentially the same, suggesting that the fewer sprays under schedule D were sufficient to control the disease.

Between the March and August observations B received 10 sprays, C received 6, and D received only 3. Disease incidence for B continued slightly downwards, for C it rose slightly, and for D it rose considerably. The D schedule during this period apparently did not predict when it was necessary to spray. The C schedule was more successful in providing needed sprays.

Between the August and October observations B received five sprays while C and D received three. The noticeable decrease in the D curve indicates that the D schedule accurately predicted periods when it was unnecessary to spray during these 3 months.

Between the October and December observations, B and C received five sprays, while D received all but the last one. The disease curves held relatively steady.

DISCUSSION

Rainfall affects the pathogen in several ways. Rain is important for disseminating the fungus. The asexual spores, or conidia, are washed from diseased leaves and are carried by raindrops (*1*). The sexual spores (ascospores) are windblown; however, they are shot off from the leaves usually during or after rain-showers (*3*). Furthermore, wet leaves are necessary for conidial production and spore germination (*1*). These three stages: Spore production, dissemination, and germination, are important in causing disease epidemics. Theoretically, therefore, rainfall should favor Sigatoka incidence.

No sprayed plot was free from disease. The lowest Sigatoka incidence was 3 percent, but in most of the sprayed plots it was between 5 and 12 percent. The lack of complete disease control might have been caused by the small-sized plots, 10 x 72 feet, subjected to unusually large quantities of inoculum.

On two sides of each plot there were five rows of unsprayed, heavily diseased plants, and 30 feet away on the windward side, there was a similar row. The amount of inoculum must have been high compared with conditions in commercial banana farms where all plants are sprayed. It is likely, therefore, that disease incidence on the sprayed plants would have been lower if this experiment could have been conducted on a larger scale.

Growers should remember that Sigatoka control alone may not be sufficient to ensure good fruit yield. Sigatoka is a major cause of low yields, but other factors, such as lack of water or fertilizer, may result in equally poor results. Spray practices should be accompanied by proper cultural practices.

The choice of the best spray schedule depends on comparing spray costs with fruit losses from disease. For the entire year, schedule B gave better disease control than C, which gave better control than D. The annual application costs also ran in the same order, *i.e.* B, C, D, and, in Puerto Rico, would have cost approximately $50, $38, and $26 per acre, respectively. Only further experiments that measure fruit yield can indicate whether the more expensive treatments will justify their costs by providing higher fruit yields.

The present experiment emphasizes two important points. First, there was a marked reduction in disease in all sprayed plots as compared with the unsprayed check plots. Second, rainfall data permitted a reduction in the number of spray applications to almost half (schedule D) without serious loss of disease control.

Of course, spray schedules based on rainfall data are not foolproof. Schedule D gave good results at the beginning and end of the year, but was not so good from March to July. Schedule C gave better control throughout the year, but more spray applications were required. The rainfall-forecasting system should be tried in other localities, with modifications if necessary, before it can be recommended for general use. This system is advantageous as compared with others suggested previously because it is based on a single weather factor that it is simple for the grower to measure and record. The present results suggest that rainfall data can often forecast when oil-sprays are needed for Sigatoka control.

SUMMARY

Banana growers require a method for deciding when to spray with oil for Sigatoka control. The possibility of using rainfall data for predicting when to spray was tested on small replicated plots of bananas. Every 2 weeks a decision on whether to spray was based on rainfall as follows: Check schedule A, no spray; check schedule B, spray every 2 weeks throughout the year, regardless of rainfall; schedule C, spray only if 3 or more inches of rain fell during the previous 3 weeks; schedule D, spray only if rainfall attained 3 or more inches during the previous 3 weeks, and exceeded the rainfall data gathered 2 weeks earlier. The experiment lasted for 1 year. The total number of applications for schedules A, B, C, and D were 0, 25, 19, and 13, respectively. All sprayed plots had significantly less disease than the unsprayed check. It is concluded that rainfall data are useful in forecasting when oil applications are needed for Sigatoka control.

RESUMEN

Los agricultores que se dedican al cultivo del guineo necesitan un método para determinar cuándo deben asperjar con aceite para combatir la Siga-

toka. Se probó en pequeñas parcelas experimentales la posibilidad de usar los datos de lluvia para predecir cuándo deberá asperjarse. Cada dos semanas se tomó la decisión de asperjar de acuerdo con la lluvia de la manera siguiente: Testigo A, sin asperjar; testigo B, asperjando cada 2 semanas durante todo el año; tratamiento C, asperjar cuando hubieren caído 3 ó más pulgadas de lluvia durante las 3 semanas anteriores; tratamiento D, asperjar cuando hubieren caído 3 ó más pulgadas de lluvia durante las 3 semanas anteriores y cuando esta lluvia fuere más alta que la anotada dos semanas anteriores. El experimento duró un año. El total de aspersiones para los tratamientos A, B, C, y D fueron 0, 25, 19 y 13, respectivamente. Todas las parcelas asperjadas demostraron, significativamente, sufrir de menos enfermedad que las parcelas testigos que no se asperjaron. En conclusión, se ha determinado que los datos de lluvia son muy útiles para predecir cuándo hay que asperjar con aceites para combatir la Sigatoka.

LITERATURE CITED

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