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Editora Contribuciones
2026



CHAPTER 6

ALTERNATIVE EQUIPMENT FOR FUNGICIDE APPLICATION TO CONTROL BLACK SIGATOKA DISEASE IN BANANAS

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ABSTRACT: Black Sigatoka (*Mycosphaerella fijiensis*) is a serious disease that makes banana cultivation unfeasible if control measures are not adopted. The objective of this study was to evaluate the efficiency of an alternative method for applying fungicides to control Black Sigatoka in banana plants. The applicator-dosifier set, as an alternative method for fungicide application, was compared with the syringe method adapted for this purpose. The following treatments were arranged in a randomized block design with five replications: (1) applicator-dosifier set, (2) adapted syringe, and (3) control. Applications consisted of depositing 5 mL/plant, comprising 1 mL of the commercial formulation of the fungicide mixture Flutriafol + Azoxystrobin diluted in 5 mL of water. Treatment effects were evaluated through statistical analysis of the mean severity of Black Sigatoka on leaves 5 to 11, severity on leaf 10, number of viable leaves per plant at flowering, and bunch weight. According to the severity analyses, in 11 of the

12 months evaluated, there was no difference in efficiency between the equipment, although both differed from the control. Regarding bunch weight, no difference was found between the applicator-dosifier set (11.2 kg) and the syringe (12 kg), but both were statistically superior to the control (9.4 kg). The applicator-dosifier set can replace the adapted syringe with the same technical application efficiency and without losses in fruit production.

KEYWORDS: *Mycosphaerella fijiensis*, Musa spp., disease control, application technology.

RESUMO: A Sigatoka-negra (*Mycosphaerella fijiensis*), é uma doença grave que inviabiliza o cultivo da bananeira, se não forem adotadas medidas de controle. O presente trabalho teve como objetivo avaliar a eficiência de método alternativo para aplicação de fungicidas para o controle da Sigatoka-negra em bananeira. O conjunto aplicador-dosador como método alternativo para aplicação de fungicidas foi comparado ao método da seringa veterinária adaptada para esse fim. Os seguintes tratamentos foram dispostos em delineamento de blocos ao acaso, com cinco repetições: 1) conjunto aplicador-dosador, 2) seringa adaptada e 3) testemunha. As aplicações foram realizadas, através da deposição de 5mL/planta, constituídos de 1 mL da formulação comercial da mistura dos fungicidas Flutriafol + Azoxystrobina diluído em 5 mL de água. O efeito dos tratamentos foi avaliado através da análise estatística da severidade média da sigatoka-negra nas folhas 5 a 11, na severidade na folha 10, no número de folhas viáveis/planta na época do florescimento e no peso de cachos. De acordo com o resultado das análises de severidade, em 11 dos 12 meses avaliados, não houve diferença entre a eficiência entre os equipamentos, porém diferentes em relação à testemunha. Em relação ao peso de cachos não houve diferença entre os tratamentos conjunto aplicador-dosador (11,2 Kg) e seringa (12 Kg), porém superiores estatisticamente à testemunha (9,4 kg). O conjunto aplicador-dosador pode substituir a seringa adaptada com a mesma eficiência técnica de aplicação sem prejuízos na produção de frutos.

PALAVRAS-CHAVE: *Mycosphaerella fijiensis*, Musa spp., controle de doença, tecnologia de aplicação.

1. INTRODUCTION

Among the various phytosanitary problems affecting banana plants, black Sigatoka, caused by the fungus *Mycosphaerella fijiensis* Morelet, is considered one of the most serious (Cordeiro; Matos, 2012). The damage caused by the disease to banana plantations is significant. The pathogen causes leaf lesions that reduce the plant's photosynthetic area and leads to high leaf mortality (Romero; Sutton, 1998), affecting fruit quality and production yield.

In regions where the disease occurs, it is the primary factor in the decline of banana plantation productivity, with significant drops in production beginning in the first growing cycle (Gasparotto *et al.*, 2007). According to Pereira *et al.* (2010), black Sigatoka is extremely destructive, as it causes premature leaf death and attacks a large number of banana cultivars, including those traditionally grown and consumed in the Amazon such as Maçã, Nanica, and Prata, as well as plantains such as Comprida, D'Angola, and BRS Terra Anã.

Integrated management is recommended for the control of black Sigatoka, such as planting resistant cultivars, cultural control, and, above all, chemical control, which is indispensable when dealing with cultivars susceptible to the disease (Cordeiro *et al.*, 2016).

Conventional chemical control, despite being the most widely used method, faces the problem of decreasing chemical efficacy due to the selection of pathogen populations resistant to the applied fungicides. This practice has required up to 56 fungicide applications per year, with short intervals between applications (Pereira *et al.*, 2000). Another difficulty encountered is the method of application, since aerial application is feasible only for large areas. Thus, small-scale producers opt for ground application, which is, however, of low efficiency, as there are difficulties in reaching the bud, the first, second, and third leaves—the sites where the pathogen causes infections (Gasparotto *et al.*, 2007). According to Pereira *et al.* (2000), this system requires adjustments to increase the interval between applications, more suitable equipment to achieve greater application efficiency, and the search for new fungicide molecules and/or formulations.

Upon evaluating fungicide application methods for the control of black Sigatoka, it was found that it is possible to reduce the number of applications to

three per production cycle and six per year by depositing the fungicide, in its commercial form, in the axil of the second banana leaf, using a veterinary syringe adapted for this purpose (Gasparotto *et al.*, 2020).

The objective of this study was to evaluate the efficiency of the “applicator-dispenser assembly” (Figure 1) compared to the adapted syringe (Gasparotto *et al.*, 2020) for the application of fungicides to control black Sigatoka.

2. METHODOLOGY

The “applicator-dispenser assembly” method was compared to the “adapted veterinary syringe” developed by Gasparotto *et al.* (2020) for the application of fungicides in the axil of the second leaf to control black Sigatoka.

The applicator-dispenser assembly (Figure 1) consists of a 5-liter manual sprayer connected to a 1.25-meter hose, linking the sprayer to a universal dispenser with a dosage range of 5 mL to 25 mL. An 18-cm metal tube is connected to the dosing device to attach the smaller-diameter tube that carries the fungicide to the application site. This tube has a variable length, depending on the height of the banana trees to be treated; it is a drawn steel tube with a curved tip and the other end bent, similar to an umbrella handle.

Figure 1. Applicator-dispenser assembly for depositing the fungicide in the axil of the banana tree.



Source: Authors.

The syringe for fungicide application is adapted by attaching a latex or silicone tube, approximately 25 cm long and 3 mm to 4 mm in diameter, to the needle site. At the other end of the tube, a drawn steel tube with a curved tip is attached; it is approximately 2 m long and has a diameter similar to the tube, with the other end curved, resembling an umbrella handle. Another hose connects the syringe to the container holding the fungicide in its commercial formulation for application (Gasparotto *et al.*, 2020).

The research was conducted during 2015 in an experimental area at Embrapa Rondônia, part of the “Pilot Project for the Use of the Depletable Zone of the Jirau Hydroelectric Power Plant (UHE) Jirau (RO) Reservoir and the surrounding dryland areas,” located in the district of Nova Mutum Paraná, in Porto Velho, RO, at the geographic coordinates 09°17'64” S and 64°35'67” W, at an altitude of 169 m.

The banana plants (Maçã cultivar) were planted in March 2013 using 6-month-old micropropagated seedlings, spaced 3 m × 3 m apart. Cultural practices, such as suckering, fertilization, defoliation, and weed management, were carried out in accordance with the banana production system for Rondônia (Costa, 2007).

The following treatments were arranged in a randomized block design with five replicates: 1) applicator-dispenser assembly; 2) adapted veterinary syringe; and 3) control. Each plot consisted of a row with 4 plants. The fungicide used in the experiment was Flutriafol (12.5%) + Azoxystrobin (12.5%), with a dosage of 1 mL/plant of the commercial product. To dilute the product and prevent clogging of the applicators, a spray mixture was prepared using a 1:4 ratio (fungicide/water), and 5 mL of the mixture was applied to the axil of the second leaf of each plant using the tested applicators.

The severity of black Sigatoka was assessed using the Stover scale, modified by Gauhl (Orozco-Santos, 1998), consisting of ratings from 1 to 6 according to the percentage of damaged leaf area, where: 1 = leaves without disease symptoms and those with up to 10 spots; 2 = leaves with <5% damaged leaf area; 3 = leaves with 6–15% damaged leaf area; 4 = leaves with 16–33% damaged leaf area; 5 = leaves with 34–50% damaged leaf area; 6 = leaves with >50% damaged leaf area.

The severity of black Sigatoka was assessed one day before each fungicide application. The applications and assessments were conducted from January to November 2015, totaling 6 applications at 60-day intervals in January, March, May, July, September, and November 2015.

Based on the assessments, the average disease severity was recorded on leaves numbered 5 through 11 (average F5/11) and on leaf number 10 (F10), and the number of viable leaves per plant (NFV) was calculated. Viable leaves were defined as healthy leaves and those whose disease severity did not exceed grade 3 on the Stover scale (Martins et al., 2016).

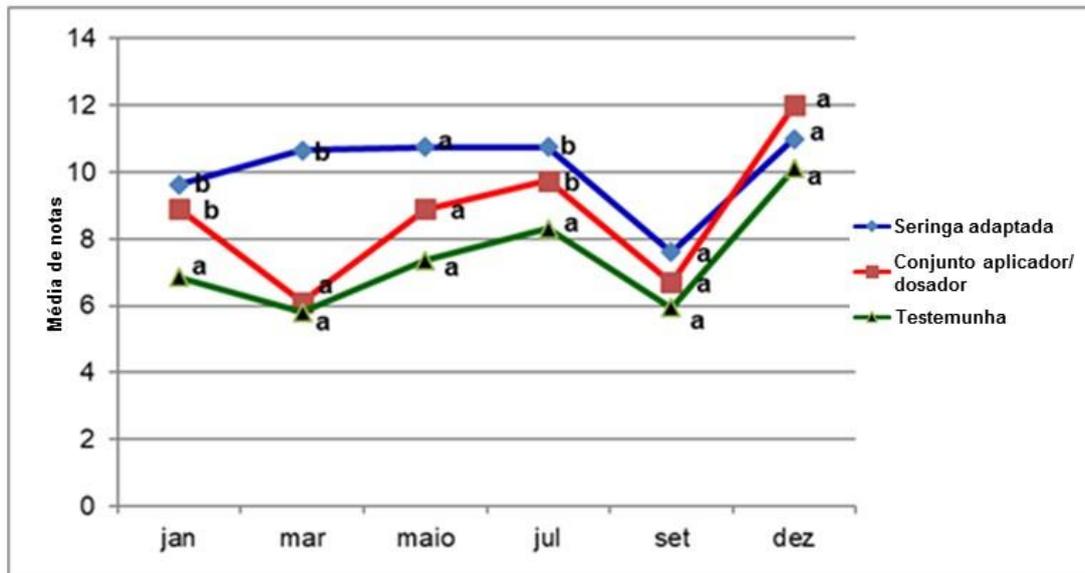
Yield was recorded by weighing the bunches weekly as they reached harvest maturity.

3. RESULTS AND DISCUSSIONS

3.1 ASSESSMENTS OF SEVERITY LEVEL

According to the results obtained, analyzing the F5/11 variable (average severity of leaves 5 through 11) (Figure 2), in March the average severity score for the treatment with the applicator-dispenser assembly was equal to that of the control. In January, May, and July, the results were the same between the treatments using the adapted syringe and the applicator-dispenser assembly, differing from the control. In September and November, there was no difference between the treatments compared to the control.

Figure 2. Average severity of black Sigatoka on leaves 5 through 11 (F5/11) as a function of fungicide application method and evaluation period.



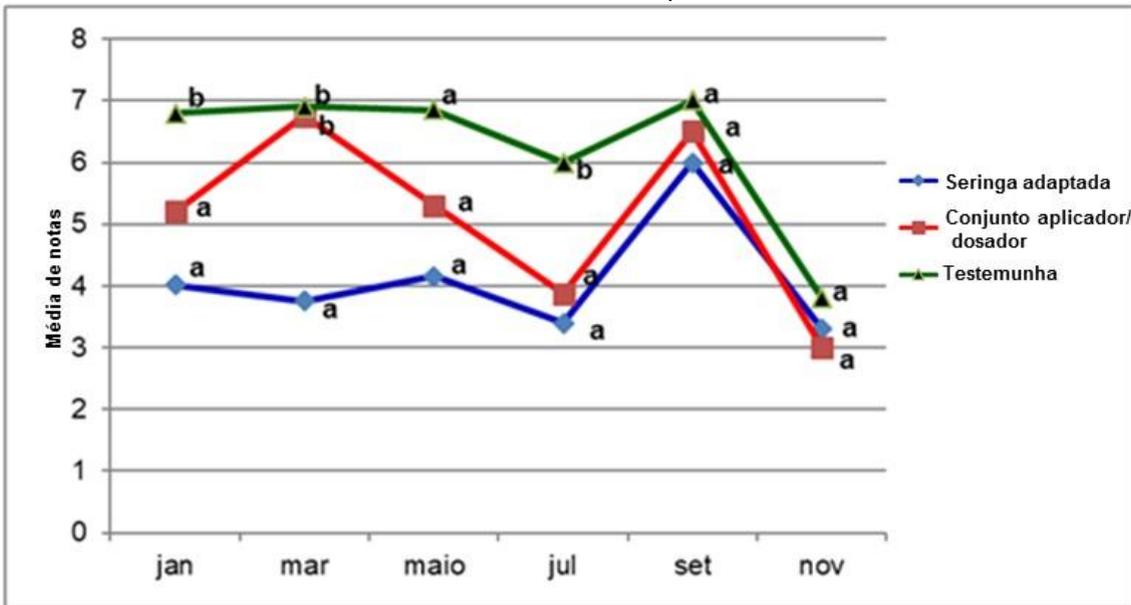
Means followed by the same letter vertically do not differ from each other according to the Scott-Knott test at a 5% probability level.

Source: Prepared by the authors.

The variation in black Sigatoka severity during the evaluation months is likely associated with fluctuations in environmental conditions, particularly relative humidity and precipitation, which influence the pathogen's life cycle and the efficacy of applications. During the rainiest months (January to March), there was an increase in average severity (F5/11 and F10), reflecting greater disease pressure and a possible reduction in the persistence of the applied fungicides. This behavior is common during periods of high humidity and temperature, in which leaf reinfection is accelerated, requiring shorter intervals between applications. According to Jácome; Schuh, 1992; Churchill, 2010; Bebber *et al.*, 2019, this behavior is consistent with the epidemiology of *M. fijiensis*, whose infection cycles are accelerated under high temperatures (25–28°C) and long periods of leaf wetness, favoring successive reinfections

The severity results for leaf number 10 (F10) (Figure 3) were statistically similar to those for variable F5/11, except in May, when there was no significant difference among treatments.

Figure 3. Black Sigatoka severity on leaf number 10 (F10) as a function of fungicide application method and evaluation period.

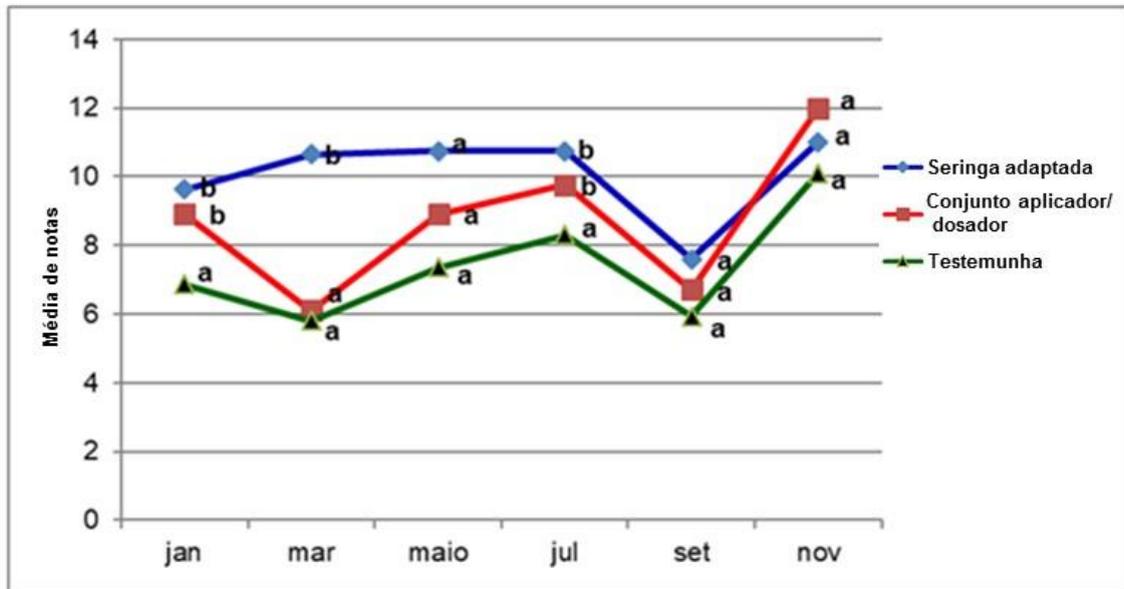


Means followed by the same letter vertically do not differ from each other according to the Scott-Knott test at a 5% probability level.

Source: Prepared by the authors.

Regarding the number of viable leaves per plant (NVL) (Figure 4), the mean of this variable was equal to or greater than 10 in the March evaluation, with a significant difference for the adapted syringe compared to the other treatments; in July, it was between the treatments with the adapted syringe and the applicator-dispenser assembly, differing from the control, and in November, it was greater than 10 for the adapted syringe and the applicator-dispenser assembly, but statistically similar to the control. The VLP indicates the productive potential of the banana plant, which should be greater than 10—r viable leaves per plant. This parameter reflects the plant's photosynthetic capacity and, consequently, the filling and weight of the bunch. A reduction in the number of viable leaves below this threshold results in lower accumulation of assimilates in the fruits (Robinson, 1996; Gasparotto et al., 2020; Olivares *et al.*, 2022).

Figure 4. Number of viable leaves (NVL) from January to November 2015, as a function of the equipment used for fungicide application.



Means followed by the same letter vertically do not differ from one another according to the Scott-Knott test at a 5% probability level.

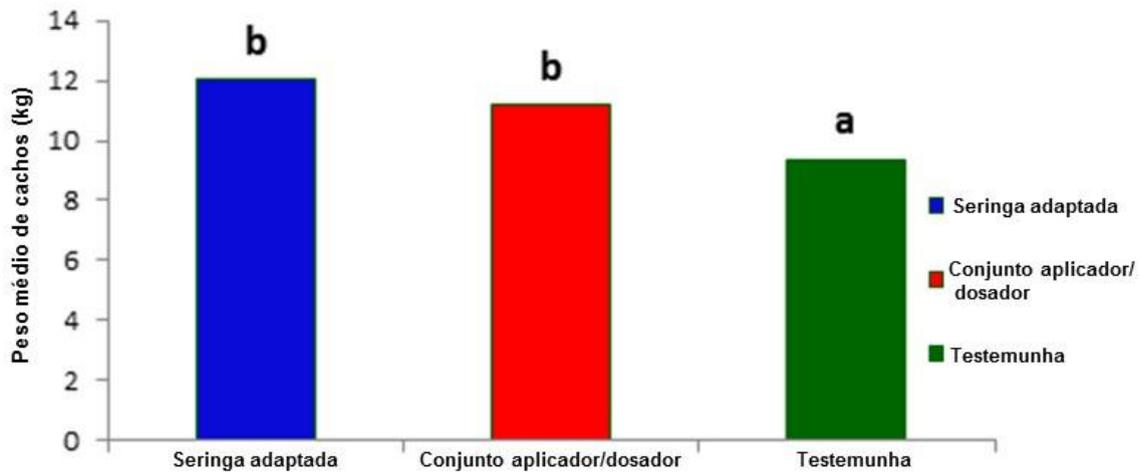
Source: Prepared by the authors.

Despite temporal variation, the two fungicide application methods—using the adapted syringe and the applicator-dispenser assembly—exhibited similar performance in 11 of the 12 months evaluated, with no significant differences in average leaf severity or the number of viable leaves per plant (NVL). This indicates that the applicator-dispenser assembly ensures efficient fungicide deposition in the leaf axil, reaching the pathogen’s target site in a manner comparable to traditional equipment. From May to September, months with lower disease severity, the equivalence between the methods was even more evident, showing that the new system maintains control stability even under lower disease pressure.

3.2 YIELD EVALUATION

The cluster weight between the treatments using the adapted syringe and the applicator-dispenser assembly was statistically similar, but statistically higher than the control (9.36 kg) (Figure 5), indicating that fungicide application with the adapted syringe can be replaced with the same efficacy by the applicator-dispenser assembly. The average weight of the bunches treated with the adapted syringe was 12 kg, and with the applicator-dispenser assembly, it was 11.20 kg.

Figure 5. Average weight of bunches without stems (kg) as a function of the equipment used for fungicide application.



Means followed by the same letter horizontally do not differ from each other according to the Scott-Knott test at a 5% probability level.

Source: Prepared by the authors.

4. CONCLUSION

Fungicide application using the applicator-dispenser assembly was effective in controlling black Sigatoka in banana plants, with results equivalent to those obtained with the adapted syringe, both in terms of reducing disease severity and fruit yield.

Therefore, the applicator-dispenser assembly can be adopted as a viable, low-cost alternative without compromising the crop's phytosanitary and productive performance. This technology expands management options for black Sigatoka, especially for small and medium-sized producers, contributing to the dissemination of more accessible and sustainable practices in disease control.

ACKNOWLEDGMENTS

The authors thank Energia Sustentável do Brasil S.A. (ESBR) and the Brazilian Agricultural Research Corporation (Embrapa Rondônia) for their financial support and assistance in conducting this research.

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