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(RESEARCH ARTICLE)

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Evaluation of the effectiveness of the main fungicides used against *Mycosphaerella fijiensis* of banana plantations in Côte d'Ivoire

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Abstract

Black Sigatoka, caused by *Mycosphaerella fijiensis* Morelet (*Pseudocercospora fijiensis* [Morelet] Deighton), is one of the most devastating diseases of banana. In commercial banana cropping systems, Black Sigatoka is mainly managed by fungicides. The emergence of resistant strains of *M. fijiensis* to commonly used fungicides has necessitated an evaluation of their efficacy on untreated (wild) populations. Our study on the effectiveness of the main fungicide molecules used in Côte d'Ivoire in the control of black leaf streak disease (BLSD) was conducted to develop new sustainable control strategies. The efficacy test of the different fungicides on *M. fijiensis* strains made it possible to classify the fungicides according to their capacity to reduce and delay the appearance of the first symptoms of the disease. trifloxystrobin (strobilurin) was most effective in controlling black stripe disease, followed by propiconazole, mancozeb and methyl thiophanate. However, the best result was obtained with mancozeb about the appearance of the first symptoms of the disease.

Keywords: Black Sigatoka; *Mycosphaerella fijiensis*; Resistant Strains; Fungicide; Effectiveness

1. Introduction

Bananas are an important staple food crop in tropical and subtropical regions of Asia, sub-Saharan Africa, and Central and South America [6]. Banana productivity remains low at 7.3 million metric tons/ha [6], due to biotic constraints caused by diseases and pests.

Black Sigatoka, also called black leaf streak disease (BLSD), caused by the fungus *Mycosphaerella fijiensis* Morelet remains the most damaging leaf disease in banana crops worldwide [11]. Discovered in Côte d'Ivoire in 1985 [12], BLSD causes yield losses that vary from 20 to 80 % depending on climate and growing conditions [13].

Chemical control using synthetic chemical pesticides is the one most used against BLSD [16]. Fungicide sprays to control this disease represent up to 30 % of the total cost of production. However, the use over time of these fungicides leads to the loss of their effectiveness through the emergence of fungicide-resistant strains [5]. Thus, the evaluation of the effectiveness of fungicide molecules used in banana plantations is necessary so that new control strategies can be developed. Thus, our work proposes to evaluate the net effectiveness of certain fungicide molecules (trifloxystrobin, propiconazole, methyl thiophanate and mancozeb) used in plantations on wild populations of the fungus *Mycosphaerella fijiensis*.

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2. Material and methods

2.1. Material

2.1.1. Plant material

Our study was conducted on the "Grand Nain¨ banana cultivar of *Musa acuminata* which is the most important dessert banana used in banana plantations in Côte d'Ivoire.

2.1.2. Chemical material

The fungicides used in our study were selected based on their frequency of use in Côte d'Ivoire to control black Sigatoka. Two types of fungicides were used: systemic and contact. The three families of systemic fungicides were:

- Antimitotic (benzimidazoles: methyl thiophanate);
- Sterol biosynthesis inhibitors (sbi: triazole: propiconazole) and
- Mitochondrial complex iii inhibitors (strobilurin: trifloxystrobin).

The multi-site contact fungicide is of the dithiocarbamate family (active ingredient mancozeb).

2.2. Methods

2.2.1. Setting up of the trial

The experiment was conducted under a shade house at the Research Station of the National Center for Agronomic Research (CNRA) in Bimbresso. The vitroplants of the "Grande Nain" banana cultivar were transplanted into 10-litre buckets. The substrate used for planting the banana trees was sterilized peat soil (mixture of earth and peat). Humus soil was collected at the CNRA station in Bimbresso and peat in the Niéky valley (Banana Cultivation Society Plantation). The mixture of humus soil and peat was made in equal proportion (1:1 by volume). The mixture was then steam sterilized [4]. The buckets were then filled to ¾ of their volume, or about 9 liters of soil per bucket. The plants were subjected to natural conditions of infestation by populations of so-called wild fungus, not benefiting from a fungicide treatment program.

2.2.2. Experimental design of the trial

Fungicide applications were started three weeks after planting the banana plants in the buckets. They were carried out over a period of five months. 1 liter of product-solvent mixture (water) was used for the treatments. Five treatments were evaluated:

- T1- Control: untreated plant
- T2- Contact: IVORY (mancozeb 8 kg/ha): 30 g of the product + 1000 ml of water.
- T3- Systemic: CALLIS (methyl thiophanate 0.4 l/ha): 40.32 ml+959.68 ml of water.
- T4- Systemic: TILT (propiconazole 0.4 l/ha): 20.85 ml of product + 979.15 ml of water
- T5- Systemic: TEGA (trifloxystrobin 1 l/ha): 70.5 ml of product + 929.5 ml of water

Applications were made with a 2-liter hand sprayer. The total number of banana plants treated was 50 with 10 plants per treatment (Figure 1).

Figure 1 Transplants of the "Grande Nain" banana cultivar transplanted into the buckets.

2.2.3. Evaluation of the effectiveness of the fungicides

Observations were made on the leaves of the banana plants and were carried out weekly. Observations started one week after the first application of fungicides. Ten banana plants were observed per treatment in this study. On the banana plants, the values of the following three parameters were determined each week:

- Youngest Leaf Spotted (YLS): The rank of the first leaf with at least 10 dashes of BLSD stage 1 [8]; [14], was recorded by observing the leaves from top to bottom (Figure 2).

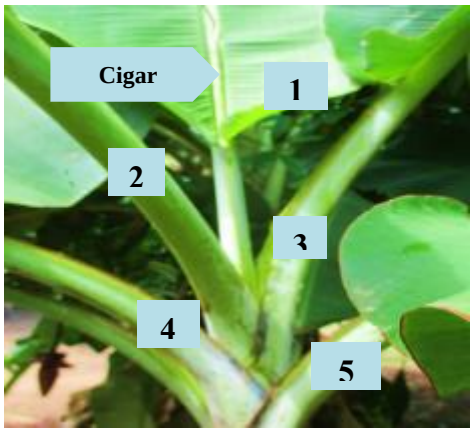


Figure 2 Leaf ranks in a "Grand Nain" banana tree

- Youngest Leaf necrosed (YLN): This parameter is defined as the rank of the youngest leaf (Figure 2) with at least 10 necrotic spots of BLSD stage 5 or 6 (Figure 3) or a large patch of leaf blade necrotic with black Sigatoka [15] [8].

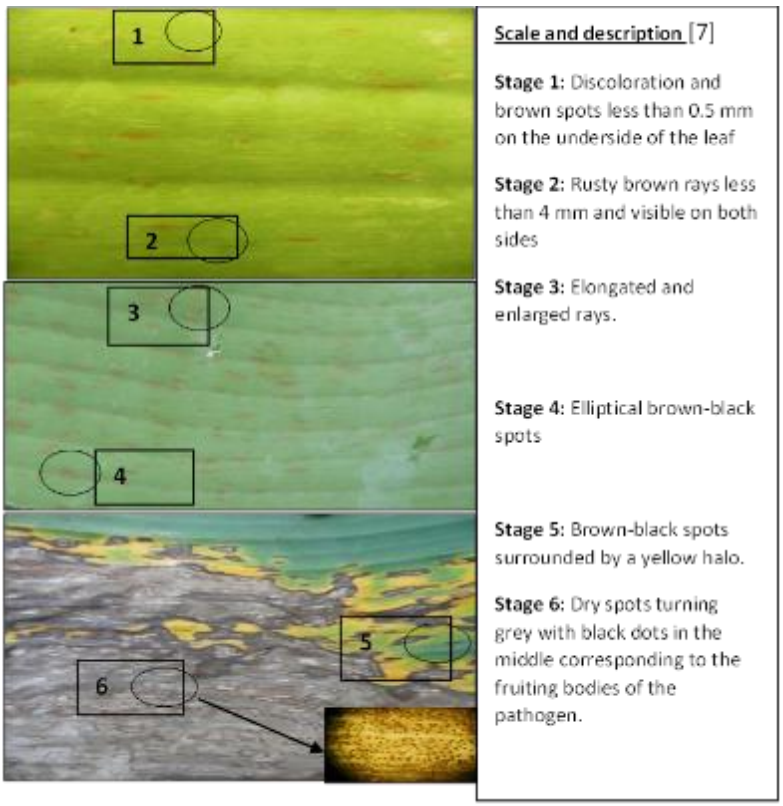


Figure 3 Description of the different stages of development of black Sigatoka in the field

- Evolution of the Disease (ED): the calculation method used was the one described by Ganry and Meyer [10] in the framework of the reasoned control of yellow Sigatoka, but slightly modified by Fouré [7] and Ganry and Laville [9] by adapting it to black Sigatoka.

$$\mathbf{ED = S.C \times L.E.R}$$

S.C: the Sum Corrected by the cigar stage obtained by deducting from the gross sum the coefficient corrected by the cigar stage.
L.E.R: the absolute value of the Leaf Emission Rate.

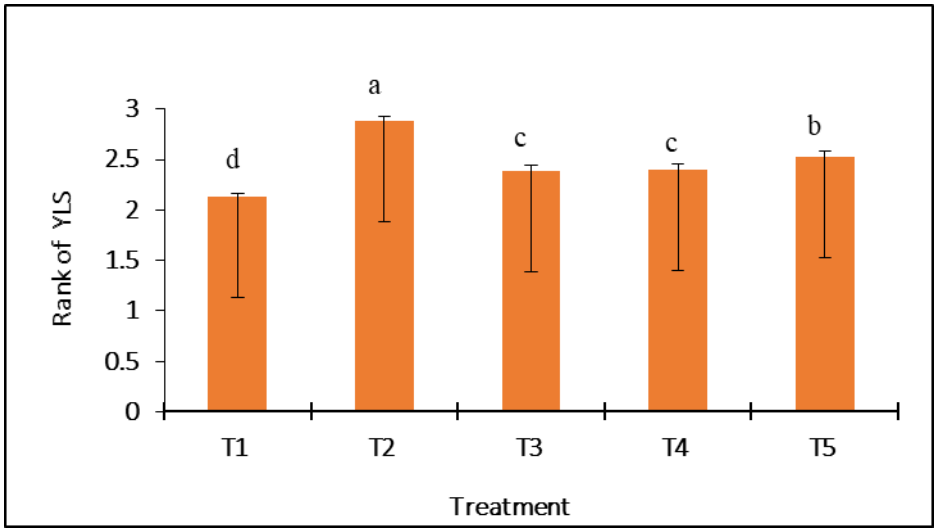
2.2.4. Statistical analysis

For the comparison of the phytopathogenic parameters (YLS, YLN, ES), a one-factor analysis of variance was performed (ANOVA I) followed by a post hoc analysis (Newman-Keuls test at the 5% threshold) using Statistica version 7.1 software. The post hoc analysis also allowed for a comparison of the net effectiveness of fungicides under natural infestation conditions.

3. Results

3.1. Youngest Leaf Spotted (YLS) by *Mycosphaerella fijiensis* by treatment.

The rank of the youngest leaf Spotted (YLS) varied over the weeks for all the treatments studied (Figure 4). The analysis of variance of banana YLS ranks showed a significant difference ($P < 0.05$) between treatments (Figure 4). Banana plants treated with mancozeb (T2) had the highest mean YLS value than those treated with the other fungicides. A comparison of the two treatments showed no significant difference between the PJFT ranks in banana plants treated with methyl-thiophanate (T3) and propiconazole (T4) (Figure 4).

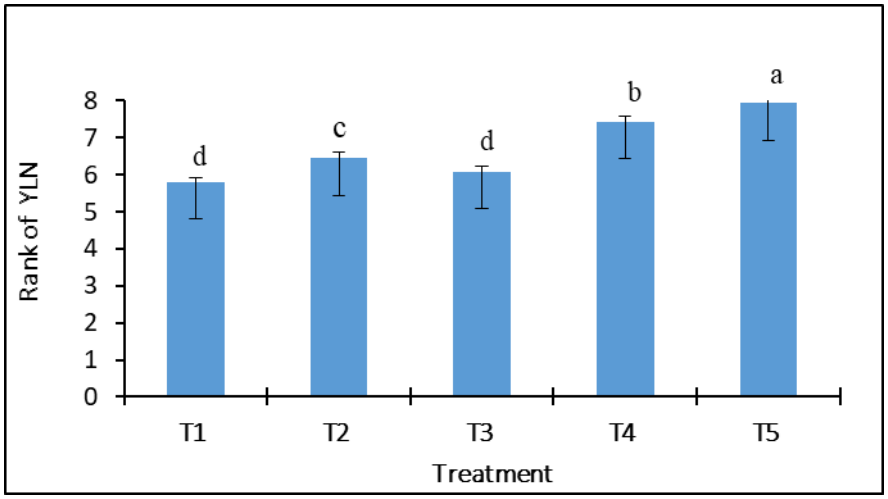


The mean values of YLS observed in the columns with the same letter are statistically equal. The mean values of YLS observed in the columns with different letters are significantly different (Newman and Keuls test α= 0.05).

Figure 4 Black Sigatoka leaf stage level (YLS) by treatment

3.2. Youngest leaf necrosed (YLN) by *Mycosphaerella fijiensis* by treatment

The youngest leaf necrosed is the first leaf with at least 10 necrotic spots starting from the cigar. As well as the youngest leaf affected, the evolution of YLN has varied over the weeks of observation. The analysis of variance of YLN ranks showed that the highest rank was obtained in banana plants of treatment T5 with a mean of 7.94. This value was significantly higher than those of banana plants of treatments T4 (7.43), T2 (6.44), T3 (6.08) and T1 (5.80). This value was significantly higher than those of banana plants in treatments T4 (7.43), T2 (6.44), T3 (6.08) and T1 (5.80). No significant difference was observed, however, between the YLN rank of control (T1) and methyl-thiophanate-treated (T3) banana plants (Figure 5).

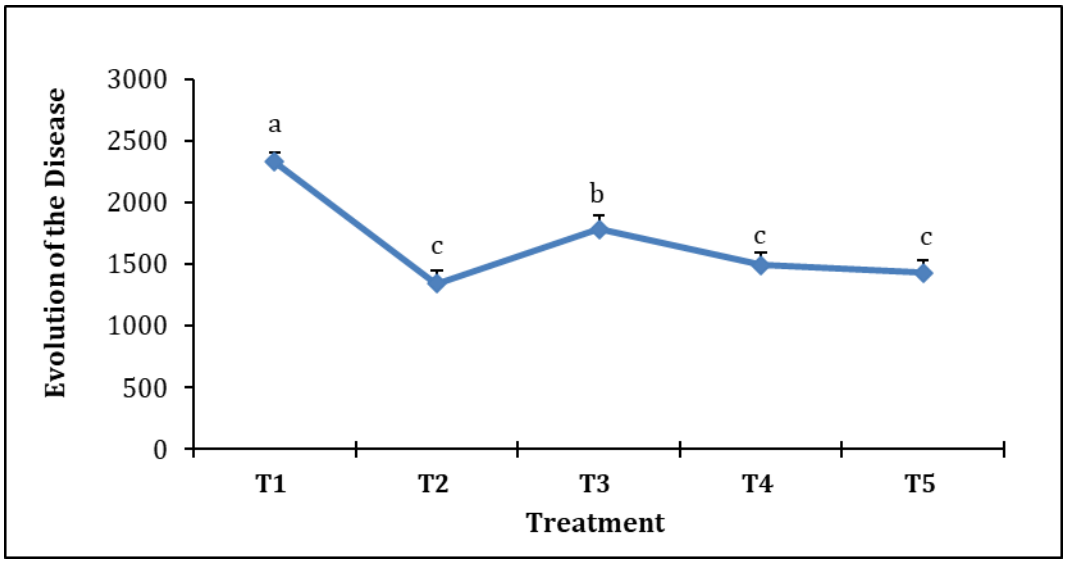


The mean values of YLN observed in the columns with the same letter are statistically equal. The mean values of YLN observed in the columns with different letters are significantly different (Newman and Keuls test α= 0.05).

Figure 5 Black Sigatoka leaf stage level (YLN) by treatment

3.3. Evolution of the Disease (ED)

The evolution of the disease (ED) was monitored consecutively each week and allowed to quantify the development of the black leaf streak disease on banana plants from the different fungicide treatments and the untreated control (Figure 6). The analysis of variance of the evolution of the disease showed that the lowest level was obtained in banana plants treated with mancozeb (T2) with a mean of 1342.9. This value was significantly ($P < 0.05$) lower than those of banana plants treated with methyl-thiophanate T3 (1786.6), propiconazole T4 (1493.1) and trifloxystrobin T5 (1429.01; Figure 51). However, no significant difference was observed between the evolution of the disease in banana plants from T2 (mancozeb), T4 (propiconazole) and T5 (trifloxystrobin) (Figure 6).



The mean values of evolution the BLSD observed in the columns with the same letter are statistically equal. The mean values of evolution the BLSD observed in the columns with different letters are significantly different (Newman and Keuls test α= 0.05).

Figure 6 Mean values of the evolution of black Sigatoka in control and fungicide treated bananas

4. Discussion

The different treatments evaluated showed different levels of efficacy on wild mushroom populations. These observations were also made by Aguilar in 2014 [1] on a study of wild populations. Results on the efficacy of some fungicides (Ivory: mancozeb, Callis: methyl-thiophanate, Tilt: propiconazole and Tega: trifloxystrobin) revealed that banana plants treated with Tega (trifloxystrobin: T5) showed fewer symptoms than banana plants treated with the other fungicides. The trifloxystrobin (strobilurin) formulation was more effective in controlling black stripe disease than propiconazole (T4), mancozeb (T2) and methyl-thiophanate (T3). Similar results have been obtained in the control

of black skate disease in Australia [17]. Indeed, the high rank of youngest leaf necrosed (YLN) after 11 spraying operations, shows that trifloxystrobin at 75 g per ha-controlled leaf lesions more effectively than all other treatments.

However, the disease severity index also showed that trifloxystrobin performed better in controlling Sigatoka disease than conventional industrial products such as propiconazole and mancozeb. At the level of disease development (ED) and the onset of first disease symptoms (YLS), the strong reduction of the disease and the delay in the onset of first symptoms was observed in banana plants treated with mancozeb (T2).

The best result obtained with mancozeb in this test can be explained by its mode of action (multi-site) and its frequency of use. Indeed, as mancozeb is a contact product, it acts directly on the fungus and when applied to the plant surface, it forms a protective barrier that is toxic to the germination of spores or to the mycelium of the fungus causing the disease [2].

The possibility to act on various sites of the fungus' metabolism and the frequency of use of mancozeb, i.e., one application per week or every ten (10) or fifteen (15) days, prevent the pathogen from developing resistance [3]. These two actions (mode of action and frequency of use) combined can therefore contribute to the slowing down of the first symptoms of Sigatoka diseases in banana.

5. Conclusion

The present study on the efficacy of different fungicides on *Mycosphaerella fijiensis* strains classified the fungicides according to their ability to reduce and delay the onset of disease symptoms. trifloxystrobin (strobilurin) was most effective in controlling black stripe disease, followed by propiconazole, mancozeb and methyl-thiophanate. However, the best result was obtained with mancozeb regarding the appearance of the first symptoms of the disease.

Compliance with ethical standards

Acknowledgements

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Disclosure of Conflict of interest

The authors declare that they have no conflict of interest regarding the publication of this article.

References

[1] Aguilar-Barragan A., García-Torres AE, Odriozola-Casas O, Macedo-Raygoza G, Ogura T, Manzo-Sánchez G, James AC, Islas-Flores I, Beltrán-García MJ. Chemical management in fungicide sensitivity of Mycosphaerella fijiensis collected from banana fields in México. Braz J Microbiol. 2014 May 19 ;45(1) :359-64.

[2] Anonymous. Banana, special agriculture (edible plants: fruit species) in Memento [of the agronomist. 5th edition. Cultivation techniques in Africa. Ministry of Cooperation and Development. Paris, France, 2002 pp 960-974.

[3] Bacon R. Fungicide Resistance Management Agricultural and Agri-Food Canada. 2002. http://www.agrireseau.qc.ca. Pdf.

[4] Céline G, Vicent M. Plants Soil disinfection by steam. Agroscope. 2016. Technical Sheet N° 34.

[5] De Bellaire LDL, Fouré E, Abadie C, Carlier J. Black leaf streak disease is challenging the banana industry. Fruits. 2010; 65 :327-342.

[6] Food and Agriculture Organization. Preliminary results of the banana market review 2020. FAO; Rome, Italy: 2021. [(cited February 8th, 2022)]. 21. [Internet]. https://www.fao.org/3/cb5150en/cb5150en.pdf.

[7] Fouré E. Banana cercospora and their treatments: Varietal susceptibility study of banana and plantain to Mycosphaerella fijiensis Morelet in Gabon. Fruits. 1982; 37: 749-771.

[8] Fouré E. Banana cercospora and their treatments. Selection of new fungicidal molecules. Comparative activities of different fungicidal molecules on Mycosphaerella fijiensis Morelet, agent of the black stripe disease of banana and plantain in Gabon. Fruits. 1983, 38: 21-34

[9] Ganry J, Laville E. Banana cercospora and their treatments. Evolution of treatment methods: 1) - General, 2) - Fungicide treatments, 3) - Warning. Fruit. 1983, 38 (2): 75-82.

[10] Ganry J., Meyer JP. Controlled control of Cercospora in the West Indies. Climatic bases of the technical warning of observation and numeration of the disease. Fruits. 1972, 27(10):665-676

[11] Hidalgo W, Chandran JN, Menezes RC, Otálvaro F, Schneider B. Phenylphenalenones protect banana plants from infection by Mycosphaerella fijiensis and are deactivated by metabolic conversion. Plant Cell Environ. 2016 Mar ;39(3) :492-513.

[12] Jacome L, Lepoivre P, Martin D; Ortiz R, Romero R, Escalant JV. Mycosphaerella leaf spot diseases of bananas: present status and outlook. 2003. 318 p. ISBN: 978-2-910810-57-3, ISBN: 2-910810-57-7.

[13] Noar RD, Thomas E, Xie D-Y, Carter ME, Ma D, Daub ME (2019) A polyketide synthase gene cluster associated with the sexual reproductive cycle of the banana pathogen, Pseudocercospora fijiensis. PLoS ONE. 2019. 14(7): e0220319. https://doi.org/10.1371/journal.pone.0220319

[14] Orjeda G. Evaluation of banana resistance to Sigatoka diseases and fusarium wilt. INIBAP Technical Guide 3. International Plant Genetic Resources Institute, Rome, Italy; International Network for the Improvement of Banana and Plantain, Montpellier, France, 63 p.

[15] Stover RH, Dickson JD. Leaf spot of bananas caused by Mycosphaerella musicola: methods of measuring spotting prevalence and severity. Trop Agric (Trinidad).1970.47: 289-302

[16] Traoré S, Kobenan K, Kouassi KS, Gnonhouri G. Plantain cropping systems and pest control methods in Ivory Coast, Journal of Applied Biosciences. 2009. 19: 1094 – 1101.

[17] Vawdrey L.L, Grice K. Field evaluation of strobilurins, triazoles and acibenzolar for control of Sigatoka disease in Australia.2005. In InfoMusa vol 14 N°2 December 2005: 11-15