REVISTA DE CIÊNCIAS AGRÁRIAS
Amazonian Journal
of Agricultural and Environmental Sciences
www.ajaes.ufra.edu.br

http://dx.doi.org/10.4322/rca.2013.045

ORIGINAL ARTICLE

Intercropping of *Maçã* and *Prata Zulu* banana cultivars for the cultural management of black Sigatoka

Plantio intercalado das cultivares de bananeira Maçã e Prata Zulu no manejo cultural da Sigatoka-negra

Luadir Gasparotto[1*]
José Clério Rezende Pereira[1]
Adônis Moreira[2]

[1]Empresa Brasileira de Pesquisa Agropecuária – EMBRAPA, Embrapa Amazônia Ocidental, CP 319, 69010-970, Manaus, AM, Brasil
[2]Empresa Brasileira de Pesquisa Agropecuária – EMBRAPA, Embrapa Soja, CP 231, 86001-970, Londrina, PR, Brasil

Corresponding Author:
*E-mail: luadir.gasparotto@embrapa.br

KEYWORDS
Mycosphaerellla fijiensis
Musa spp.
Cultural control

PALAVRAS-CHAVE
Mycosphaerellla fijiensis
Musa spp.
Controle cultural

ABSTRACT: In this study, we assessed the effect of intercrop planting of *Maçã* and *Prata Zulu* banana cultivars in the reduction of black Sigatoka severity and in the productivity of the *Maçã* cultivar. The treatments used were a combination of 5, 10, 15, 20 and 25% of plants of the *Maçã* cultivar distributed in plots with 95, 90, 85, 80 and 75% of plants of the *Prata Zulu* cultivar. Four months after planting, 20 leaves infected with black Sigatoka were distributed at each plot of 200 plants as a source of inoculum. The plots were separated by strips of secondary forest approximately 20 m wide and 15 m high. Each plot was divided in four subplots. Severity evaluation was performed in leaf number 10 during the flowering period. The number of viable leaves and the weight of production (bunches, hands and fruits) were also assessed. The statistical analyses did not show differences between the treatments used. Intercrop planting was not effective in reducing the severity of black Sigatoka in the *Maçã* cultivar and the yield was similar to that observed in monocultures.

RESUMO: *Avaliou-se o efeito do plantio intercalado da cultivar Maçã com a cultivar Prata Zulu na redução da severidade da doença sigatoka-negra e na produção da cultivar Maçã. Os tratamentos consistiram do plantio de 5, 10, 15, 20 e 25% de plantas da cultivar Maçã, distribuídas dentro de talhões com 95, 90, 85, 80 e 75% de plantas da cultivar Prata Zulu, respectivamente, perfazendo um total de 200 plantas por talhão. Quando as plantas atingiram quatro meses de idade, em cada talhão foram distribuídas 20 folhas com sigatoka-negra, como fonte de inóculo. Os talhões foram separados por uma faixa de floresta secundária com cerca de 20 m de largura e 15 m de altura. Cada talhão foi dividido em quatro parcelas. No florescimento, registraram-se, na cultivar Maçã, a severidade da sigatoka-negra na folha número 10 e o número de folhas viáveis, registrando-se também, na colheita, o peso dos cachos, das pencas e dos frutos. As análises indicam que todos os tratamentos foram iguais entre si. O plantio intercalado não reduziu a severidade da doença e a produção foi semelhante às registradas em monoculturas com a cultivar Maçã.*

Received: 06/03/2013
Accepted: 07/16/2013

1 Introduction

Banana cultivation is of great social and economic importance in the state of Amazonas, Brazil. This activity contributes to keeping workers in rural areas because, besides allowing the intensive use of the area explored, it uses significant amount of labor in its cultivation and its consumer product is part of the staple diet of local populations (PEREIRA et al., 2000; GASPAROTTO et al., 2008).

Despite its importance, the state production does not meet domestic demand. Since 1998, with the discovery of black Sigatoka (*Mycosphaerella fijiensis* Morelet) in the region (PEREIRA et al., 1998), banana production has reduced dramatically because the disease causes up to 100% yield losses in the *Maçã* (triploid AAB), *Prata* (triploid AAB) and *plátano D'Angola* (triploid AAB) cultivars, the most commonly grown in the state of Amazonas (GASPAROTTO et al. 2008). Black Sigatoka causes premature leaf dry, and as plants emit no new leaves after flowering, leaves are completely destroyed approximately 40 days after bunch emission. As a result, there is no photosynthesis, hence the fruits do not develop, they become thin and small with early and uneven maturation, presenting no commercial value (PEREIRA et al., 2000; GASPAROTTO; PEREIRA, 2009).

The application of fungicides for the control of black Sigatoka in susceptible cultivars implemented in the constantly wet Amazon is not recommended, because the region presents high biodiversity, extensive water sources, and subsistence farming (PEREIRA et al., 2000). In this context, the planting of productive and resistant cultivars is a viable alternative (GASPAROTTO; PEREIRA; PEREIRA, 2002).

New control technologies should be assessed to enable the planting of cultivars susceptible to black Sigatoka. One of the alternatives that deserve to be investigated is the intercropping of susceptible and resistant banana cultivars. Cultivars that can naturally coexist with the disease may act as a barrier, hindering the spread of the *M. fijiensis* fungus spores, reducing disease progression, and allowing greater production per number of cycles of culture.

Considering the economic potential of the *Maçã* cultivar and the need to reduce economic and environmental costs, the purpose of this study was to assess the effect of intercrop planting of the *Maçã* cultivar – susceptible to black Sigatoka and the *Prata Zulu* cultivar – resistant to black Sigatoka. Intercropping may act as a barrier to the dissemination of the pathogen reducing disease severity in the *Maçã* cultivar even in areas with low incidence of the disease, enabling commercial production.

2 Materials and Methods

The experiment was carried out at "Embrapa Amazônia Ocidental" (3° 8' 25" S and 59° 52' W) in a very clayey (730 g kg^{-1} of clay) Dystrophic Oxisol of low natural fertility, with prevalence of H^{+}+Al^{3+} in the cation exchange capacity (MOREIRA; FAGERIA, 2009). The region presents wet tropical climate according to Köppen classification with relatively abundant rainfall throughout year (average of 2.250 mm), with rainfall greater than 60 mm in the driest month. The average annual temperature is approximately 26 °C (ANTONIO, 2010).

The following were added to the planting hole (50 × 50 × 50 cm): 400 g dolomitic limestone (PRNT = 85%); five liters of chicken manure (organic carbon = 296 g kg^{-1}, P = 16 g kg^{-1}, K = 11 g kg^{-1}, Mg = 16 g kg^{-1}, Ca = 65 g kg^{-1}, N = 69 g kg^{-1}); 50 g of FTE-BR12® (1.8% B, 0.8% Cu, 3.0% Fe, 2.0% Mn., 0.1% Mo and 9.0% Zn); also, 240 g of single superphosphate (20% P2O5) was added as topdressing not incorporated into the soil. In the 2nd, 4th, 7th, 10th months after planting, 132 g of ammonium sulfate – $(NH_4)_2SO_4$ (20% N) and 270 g of potassium chloride – KCl (60% K_2O) per plant were distributed by a spinner box spreader. In the 13th month after planting, 400 g of dolomitic limestone, 50 g of FTE-BR12®, 240 g of single superphosphate (20% P2O5), 132 g of ammonium sulfate, and 270 g of potassium chloride were added, per plant, as topdressing (BORGES et al., 1995; MOREIRA et al., 2005). We used an experimental design in randomized blocks with four replications. The treatments used were a combination of 5, 10, 15, 20 and 25% of plants of the *Maçã* cultivar distributed equidistantly in plots with 95, 90, 85, 80 and 75% of plants of the *Prata Zulu* cultivar, respectively, totaling 200 plants per plot, spaced 3.0 m apart in the row and 3.0 m between rows. The plots were separated by a strip of secondary forest approximately 20 m wide and 15 m high. We used a completely isolated area to ensure the source of inoculum. The area used and its surroundings presented no sign of the disease. When the plants reached four months of age, the inoculum was deposited on the edge of the plots by means of 20 leaves of black Sigatoka. Each plot was divided in four subplots. During the flowering period, the number of viable leaves per plant and the disease severity in leaf number 10 were evaluated only in the first two production cycles of the *Maça* cultivar, because in the third cycle plants showed no fruits suitable for commercialization.

For severity assessment, we used the Stover scale, modified by Gauhl (OROZCO-SANTOS, 1998), where: 1 = leaves with no symptoms of the disease and those with up to 10 spots, 2 = leaves with lesioned foliar area < 5%, 3 = leaves with 6-15% lesioned foliar area, 4 = leaves with 16-33% lesioned foliar area, 5 = leaves with 34-50% lesioned foliar area, and 6 = leaves with lesioned foliar area > 50%. Healthy leaves and leaves rated up to 3 in the Stover scale were considered viable. At harvest, we assessed the height and diameter of the pseudostem and the weight of production (bunches, hands and fruits) of the *Maçã* cultivar plants. Data were subjected to analysis of variance (ANOVA), the F test, and correlation (number of viable leaves and fruit weight) at 5% significance level according to the methods described in Pimentel-Gomes and Garcia (2002).

3 Results and Discussion

In all treatments, the number of viable leaves per plant, the severity of black Sigatoka in leaf 10, and the production data showed no significant statistical differences (Table 1). Plants of the *Maçã* cultivar presented, at flowering, approximately 10 viable leaves and low disease severity and, at harvest, bunches weighing approximately 15 and 17 kg in the first and second

Table 1. Number of viable leaves (NVL); severity in leaf number 10 (SEV10); and bunch, hand and fruit weight in two production cycles of the *Maçã* cultivar intercropped with the *Prata Zulu* cultivar at different combinations. Manaus, 2010.

Treatments[1] (%)	NVL*		SEV10**		Bunch weight (kg)		Hand weight (kg)		Fruit weight (g)	
	1st cycle	2nd cycle	1st cycle	2nd cycle	1st cycle	2nd cycle	1st cycle	2nd cycle	1st cycle	2nd cycle
5	11.15	10.48	2.87	2.40	14.57	18.95	2.23	2.20	140.7	129.5
10	10.92	10.50	2.95	2.88	14.65	15.10	2.13	1.85	132.3	112.9
15	10.57	10.62	3.00	2.60	14.82	16.82	2.23	2.08	138.4	122.2
20	10.55	10.45	3.12	2.63	15.05	15.25	2.10	1.88	133.4	109.8
25	10.87	10.33	2.95	2.95	14.50	16.93	2.18	1.98	138.8	118.9
ŷ	11.09	10.58	2.88	2.44	14.64	17.78	2.21	2.12	137.5	125.9
Mean	10.81	10.48	2.98	2.69	14.72	16.61	2.17	2.00	136.7	118.7
CV(%)	4.77	3.90	6.95	3.15	11.87	9.88	4.83	9.49	4.61	6.22

[1]Corresponding to the production of plants of the *Maçã* cultivar intercropped with plants of the *Prata Zulu* cultivar. *NVL – Number of viable leaves; **SEV10 – Percentage of lesioned foliar area (data were transformed to $\sqrt{x}$). Means of the variables analyzed within the same column are not significantly different by the F test at 5% probability level.

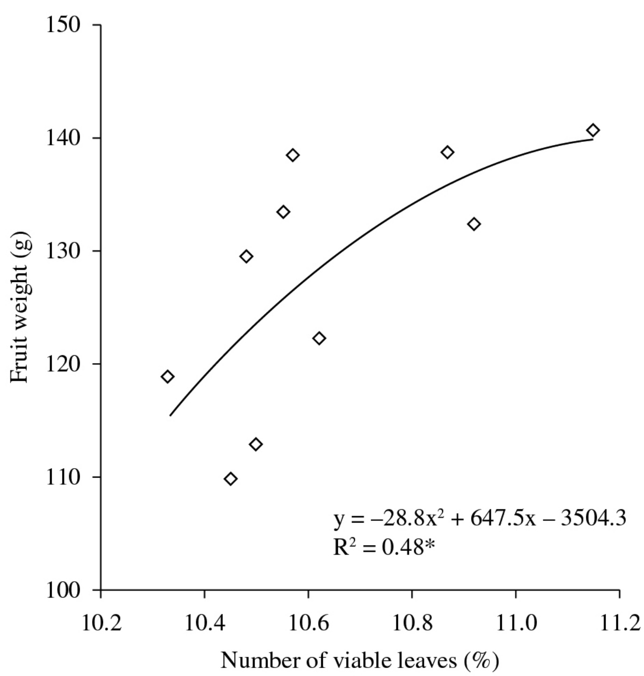

Figure 1. Ratio between the number of viable leaves and fruit weight of the *Maçã* cultivar 50 days after emission of bunches. Manaus, 2010. Significant at 5% by the F test.

cycles, respectively, with fruits suitable for commercialization. Nevertheless, approximately 50 days after the emission of the bunch, most plants of the *Maçã* cultivar presented 100% of dead leaves as a result of the attack of black Sigatoka, which was verified by the significant correlation between the number of viable leaves and fruit weight (Figure 1).

Infestation of the *Maçã* cultivar plants with external inoculum at four months of age, contributed to accelerate the progress of the disease even in the presence of plants with high resistance. In the absence of artificial infestation by deposition of banana leaves and consequent reduction in the progress of black Sigatoka, the productivity of the *Maçã* cultivar would have probably been greater, at least until the second and/or third cycles.

Cultivars with cylindrical fruits, that is, with no edges, at the stage of harvest, such as *Maçã*, *Caru-roxa* and *Caru-verde* (SILVA et al., 1995), present a certain level of tolerance to black Sigatoka, because even losing all leaves approximately 45 to 50 days after flowering are able to produce commercially suitable fruits. However, as from the third production cycle, the plants begin to wilt, culminating in a marked reduction in production and in the subsequent abandonment of planting.

4 Conclusions

Planting of the *Maçã* cultivar – susceptible to *M. fijiensis*, intercropped with the *Prata Zulu* cultivar – resistant to the disease, did not reduce the severity of black Sigatoka in banana plants.

Regardless of the degree of disease infestation, the productivity of the *Maçã* banana cultivar is severely affected.

Acknowledgements

The authors are grateful to "Fundação de Amparo à Pesquisa do Estado do Amazonas – FAPEAM" for the financial support given to this research and to Mr. Ricardo Pessoa Rebelo, laboratory technician, "Embrapa Amazônia Ocidental", for the collection of data.

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