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Severity of banana leaf spot in an intercropping system in two cycles of banana Prata Anã

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ABSTRACT – *Prata Anã is the most planted banana cultivar in northern Minas Gerais, Brazil. It is however susceptible to several pathogens. This study was carried out to evaluate the disease severity of banana leaf spot in the Prata Anã cv. in the first and second cycle under six different planting systems. The randomized block experimental design was used with six treatments and four replications. In an evaluation of the severity of banana leaf spot, no disease symptoms were found on Thap Maeo and Caipira. The evolution curve of the disease indicated seasonal effects in the first and second cycles. The severity of banana leaf spot was highest soon after the regional rainy period from November to March. A comparison of the means of the evaluations indicated a reduction in disease severity from the first to the second cycle.*

Key words: *Musa* spp., *Mycosphaerella musicola*, disease severity, multi-rows.

INTRODUCTION

In Brazil, banana is produced in all states. The production area covers approximately 509 thousand hectares and the output reaches about seven million tons of fruit (IBGE 2008). The western countries account for one third of this production (Alves 1997). Banana is worldwide one of the most traded fruits, since it represents around 10% of the world fruit market, reaching an annual U$ 5 billion, approximately (Borborema 2003). Brazil is worldwide the second largest producer of this musaceous crop, accounting for approximately 9.5% of the total production (FAO 2007). Nowadays, Brazil is the second world's largest banana market. The fruit is the most consumed fruit in the country, since the per capita consumption reaches 28.70 kg year^{-1} (FAO 2004). The internal market consumes practically the entire national production and only 3.25% of the total production is exported to other countries, i.e., Argentina, the United Kingdom, Italy and Uruguay (Agrianual 2005).

In 2007, the state of Minas Gerais ranked fifth with a yield of 537,778 tons from a production area of 36,627 thousand hectares and a production of 14,683 kg ha^{-1} (IBGE 2007). In 2004, 36,073 thousand banana bunches were harvested in Minas Gerais State, representing a mean yield of 1,115 bunches ha^{-1}. In northern Minas Gerais, mainly in the counties of Jaíba and Janaúba, the yield of irrigated banana exceeds the state mean by 70%,

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reaching 1,900 bunches ha^{-1} (Agrianual 2005). From the social point of view, the irrigation projects generate approximately 12,200 direct and 24,400 indirect jobs (Embrapa 2000).

Prata Anã cv. is the main banana type planted in northern Minas Gerais, where more than 90% of the 10,000 ha of this cultivar are planted. In other words, the economy of this region is based on a cultivar that is susceptible to several phytosanitary problems, as for example banana leaf spot, that make it vulnerable. Although less destructive than black leaf streak disease, caused by the anamorph phase of *Mycosphaerella musicola* Leach, banana leaf spot caused by *Pseudocercospora musae* (Zimm.) Deighton is still the disease with the strongest economical impact on banana in Brazil due to the large destruction, causing premature leaf death and consequent yield losses of up to 50% (Martinez 1970, Cordeiro et al. 2005). Either the sexual ascospore or the conidial asexual phase are conditional for the disease development. The ascospore phase represents the primary inoculum and the conidial phase ensures a fast pathogen multiplication. The disease development is strongly affected by climatic factors such as wind, air humidity and temperature. The incubation period also depends thereon and may vary from 15 to 76 days (Stover 1968, Cordeiro and Kimati 1997). Although both phases are important for the epidemiology of *Mycospaherella musicola*, there are still doubts in the available literature as to the functions of wind and water to disperse this pathogen. Some studies indicate that conidia dispersion occurs primarily via surface water and rainwater washing conidia off the leaves (Leach 1946, Meredith 1962, Stover 1970) and by air (Gauhl 1994), whereas other studies indicate wind as the main transport mean in ascospore dispersion (Meredith et al. 1973, Gauhl 1994).

According to Robinson (1996), the control of banana leaf spot is very costly, causes environmental damages and can quickly lead to the development of product resistance. Due to intense use of agrochemicals, consumers are increasingly concerned with the quality of food products and with residues of such agrochemicals in foods (Finckh et al. 2000).

One strategy to solve the main phytosanitary problems is to establish resistant cultivars (Silva et al. 2002). Besides, some other strategies are available, such as the use of multi-rows with the mixture of different lines with different resistance alleles (Ghini and Bettiol 2000). The mixture of resistant and susceptible cultivars in different planting systems can serve as a physical barrier against the dispersion of the fungal spores and may reduce the amount of spores in the area (Cowger and Mundt 2002). According to Becker and Léon (1988), the mixture of different genotypes, aside from reducing the disease, increases the stability of the genotypes towards varied environmental effects.

According to Lannou and Pope (2001), the genetic diversity in the pathogen population in a mixture of varieties is higher than in a single resistant variety. There are virulent and nonvirulent spores. Another mechanism to reduce the diseases in the mixtures is therefore the induction of resistance reactions against virulent races by non-pathogenic spores in tissues. The competition between different pathogen races for the same host tissue can reduce the disease severity. The spores of the non-pathogenic agents may therefore be effective in reducing the epidemic by protecting susceptible tissue areas. This mechanism was described by Finckh et al. (2000) as well.

The objective of this study was to evaluate the severity degree of banana leaf spot in the first and second cycle of Prata Anã cv., in six planting systems in the soil-climate conditions of northern Minas Gerais.

MATERIAL AND METHODS

This study was implanted in 2004, on an experimental farm of the project “Crer-Ser” together with the Universidade Estadual de Montes Claros - UNIMONTES, in the county of Janaúba, MG (lat 15º 48' 09" S, long 43º 18" 32', 533 m asl). The soil in the areas is classified as Alluvial, quite heterogeneous and stratified, with decreasing organic carbon contents with depth. At the site, the mean annual precipitation was 900 mm, mean temperature 25 ºC and the relative air humidity 56% (Figures 1, 2 and 3). The experiment was conducted with micropropagated plants, from the company Campo Biotecnologia in Paracatu, MG, and from Embrapa Mandioca e Fruticultura in Cruz das Almas, BA. The crop was irrigated with a microsprinkler system. For an adequate irrigation management, the water requirements of banana plants were determined based on the prefixed frequency, soil characteristics and atmospheric conditions. The cultural treatments were based on technical recommendations of Alves (1999).

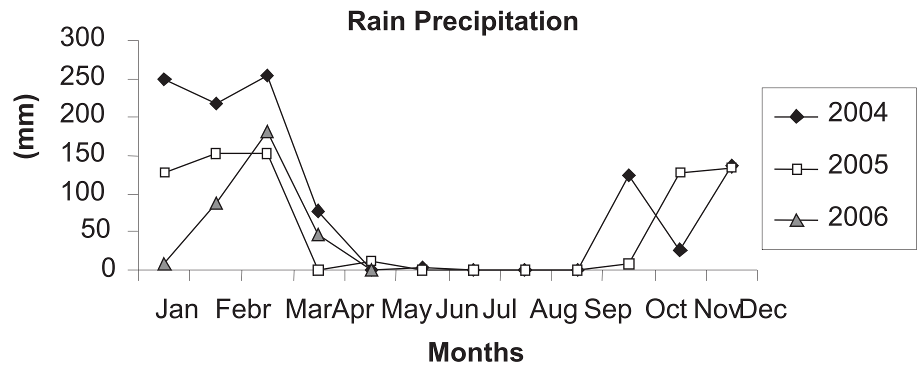

Figure 1. Rainfall index in 2004, 2005, and the first five months of 2006 (Source: Epamig 2006)

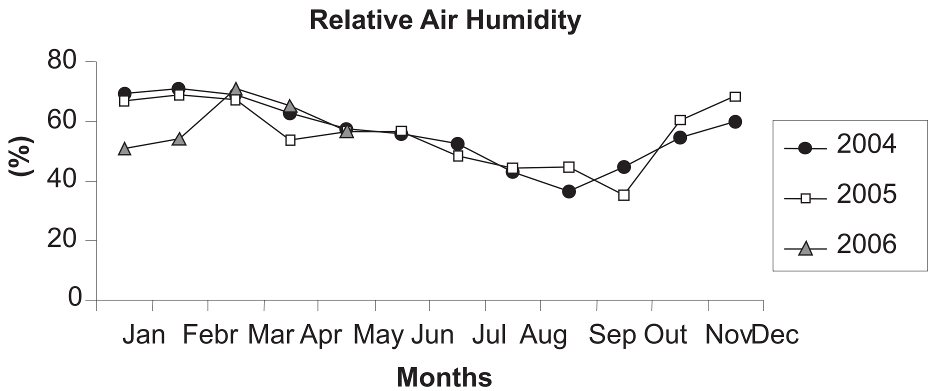

Figure 2. Relative air humidity indexes in 2004, 2005, and the first five months of 2006 (Source: Epamig 2006)

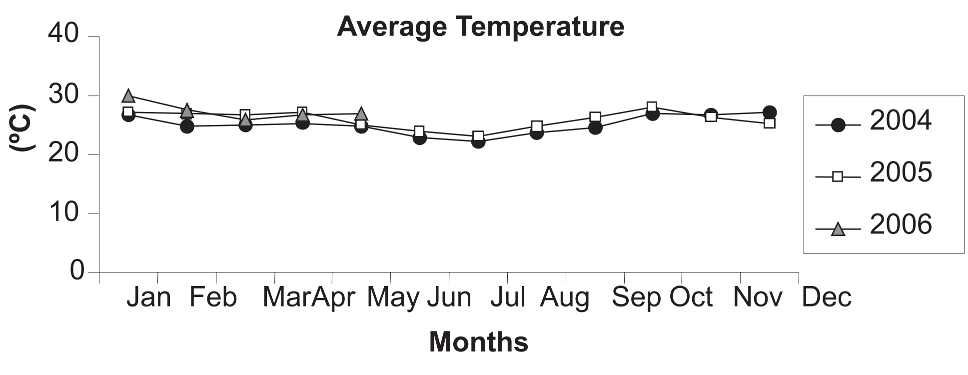

Figure 3. Mean temperature indexes in 2004, 2005, and the first five months of 2006 (Source: Epamig 2006)

The vitroplants were planted in the field on May 3, 2004 in rectangular spacing (3.0 x 2.0m).

The disease severity degree of banana leaf spot was evaluated monthly beginning in the 4th month after planting in the first cycle, using the fifth completely unrolled leaf until flowering and from the fourth month after plant emergence in the second cycle until flowering, by the Stover diagrammatic scale modified by Gauhl (1994), with values ranging from 0 to 6 as a function of the percentage of injured leaf area. At flowering, the disease severity was evaluated in the fifth leaf. No chemical control was applied in the first and second cycle of the six planting systems to control banana leaf spot.

The experiment had a randomized block design and three cultivars were used: Prata Anã, Thap Maeo and Caipira (Table 1) and six planting systems: 1) control-exclusive planting of Prata Anã cv.; 2) Prata Anã cv. intercalated with the cultivars Thap Maeo and Caipira; 3) Prata Anã cv. with one border row of Thap Maeo; 4) Prata Anã with two border rows of Thap Maeo; 5) Prata Anã cv. with one border row of Caipira; 6) Prata Anã cv. with two border rows of Caipira, with four replications and six useful plants per plot (Figures 4 and 5).

Since the severity of banana leaf spot was classified as a discrete quantitative variable, inferred from the severity degree grades, the GLM (General Linear Model) procedure was used to test the additivity, normality and homogeneity of variance. Variance analysis was performed for the trait under evaluation and the treatment means were compared by the Tukey test at 5% probability. The analysis was performed using the statistical software SAS (SAS 2000) according to the following statistical model:

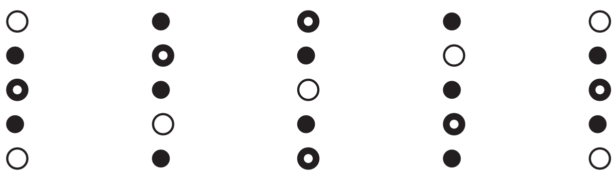

Figure 4. Schematic representation of treatment 2, with intercalated planting of the hybrid cultivars Prata Anã, 'Thap Maeo' and Caipira. ○ Thap Maeo; ◉ Caipira; ● Prata Anã

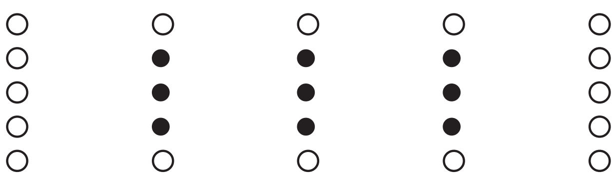

Figure 5. Schematic representation of the treatments with one border line. ○ Hybrid cultivars Thap Maeo or Caipira; ● Prata Anã

$$Y_{ij} = \mu + T_i + B_j + e_{ij}$$

where

Y_{ij} = observation for treatment *i* , in block *j*;

μ = general mean;

T_i = effect of treatment *i*, where *i* = 1, 2,..., 6;

B_j = effect of block *j*, where *j* = 1, 2,..., 4;

e_{ij} = independent experimental error associated with all values observed, with normal hypothetical distribution, with zero mean and ó^2 variance.

The means of the second one were transformed as follows: Second cycle: v x.

RESULTS AND DISCUSSION

In both cycles under analysis, no disease symptoms caused by *Mycosphaerella musicola* were found on the cultivars Thap Maeo and Caipira, corroborating results of Gasparotto et al. (1999). These researchers evaluated the cultivars Caipira and Thap Maeo in the Amazon area for both Sigatokas and found that they are resistant.

No significant differences among all six treatments in the first cycle were observed for disease severity in Prata Anã cv., with a mean disease degree of 1.43 (corresponding to 5% of the mean injured leaf area). The disease evolution curve (Figure 6) in the first cycle indicates a seasonal effect on severity from March to June of 2005, which decreased to marginal levels in the period from July to August. The months from November to March in the semi-arid region of northern Minas Gerais correspond to the rainy season (RH 63%), with a mean temperature of 27 ºC. The increase in disease severity was observed immediately after the rainy period. This result indicates the importance of humidity and temperature for the epidemiology of this disease (Stover 1968). According to Cordeiro and Kimati (1997), Sigatoka spots are strongly affected by environmental factors such as air humidity, temperature and wind. Germination

Table 1. Characteristics of resistance, ploidy and genomic group of the cultivars Prata Anã, Thap Maeo and Caipira

Characteristics of Resistance	Cultivars/Ploidy/Genomic Group		
	Prata Anã Triploid (AAB)	Thap Maeo Triploid (AAB)	Caipira Triploid (AAA)
Sigatoka Leaf Spot	S	R	R
Black Sigatoka	S	R	R
Fusarium oxisporum	S	R	R

S = susceptible; R = resistant. Source: Silva et al. (1998)

can occur when a water film covers the leaves, mainly the most susceptible ones. The incubation period depends on the climatic conditions, varying from 15 to 76 days. In 2004, the rainy season began in mid-October and the rainfalls diminished in December. Rainfall means above 200mm (Figure 1) were observed in the months from January to mid-April**,** and an increased disease severity was observed 60 days after this increase in the observed rainfall values (Figure 6). In separate treatment analyses, it is observed that the curves follow the same tendency with small variations in the months under evaluation.

Significant differences in the disease severity degree were observed in the second cycle (Table 2). In planting system 1, control (exclusive planting of Prata Anã) the mean disease severity degree was lowest (mean degree of 0.32). The cultivars Thap Maeo and Caipira are taller than Prata Anã, so these cultivars may have shaded the Prata Anã plants. Leaf shading favors a higher relative humidity and reduced brightness, which are relevant factors for the pathogen development (Bergamin Filho 1995, Silva et al. 2002). The treatments with a mixture of cultivars and the use of borders may have promoted more shading on the leaves and consequently favored the development of *Mycosphaerella musicola*.

In the second cycle a significant reduction in the disease severity was observed in the period from January to November 2005 (Figure 6). When comparing the results of the second cycle, of the mean of 10 spots leaf^{-1} with the first cycle and mean of 5% of injured leaf area, both in the months of highest disease severity, a reduction was observed from the first to the second cycle of evaluation. The same seasonal effect was observed in the second cycle in the period March through June, although at a lower intensity. These results reaffirm the importance of climatic factors such as rainfall, air humidity and temperature in epidemiology of the pathogen (Stover 1968). In the second cycle, disease severity increased in the first fortnight in March

Table 2. Disease severity degree represented by the score means according to the Stover scale modified by Gauhl (1989) in the second cycles of the Prata Anã banana cultivar, in six planting systems

Planting systems[1]	Severity Degree[2]
1	0.31623 B
2	0.46472 B
3	0.43959 B
4	0.38172 B
5	0.41447 B
6	0.51865 A

[1] 1) Control - exclusive planting of Prata Anã cv.; 2) Prata Anã cv. intercalated with the cultivars Thap Maeo and Caipira; 3) Prata Anã cv. with one border row of Thap Maeo; 4) Prata Anã cv. with two border rows of Maeo; 5) Prata Anã cv. with one border row of Caipira; 6) Prata Anã cv. with two border rows of Caipira
[2] Means followed by the same capital letters do not differ by Tukey test (P> 0.05)

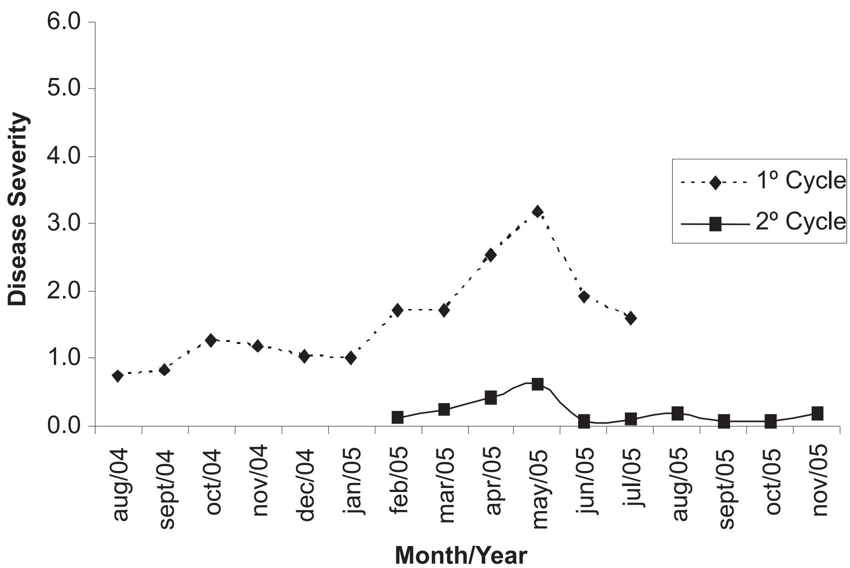

Figure 6. Evolution of banana leaf spot represented by the mean of the scores according to the Stover scale modified by Gauhl (1994), in the first and second cycles in six planting systems

2005, and highest means were registered in mid-May of the same year. From January to March 2005 (Figure 1), monthly precipitation means above 100mm were measured in northern Minas Gerais, and disease severity also increased around the 60th day after the increase in the precipitation index. In the period from July to December 2005, a period with low relative humidity and constant temperature, it decreased to very low levels (Figure 2 and 3). Among the active mechanisms of the variety mixtures, the reduction of the disease may occur due to the reduced number of susceptible plants in the plantation, by consequently reducing either the amount of inocula and/or the probability that spores would fall on susceptible plants (Wolfe and Gacek 2001). Similar results were found by Munk (2002), who reported some advantages of a mixture, e.g., the protection against air-propagated pathogens (rusts, mildews, septoriosis, cercosporiosis**)** and protection against cold injuries. According to Liebman (1989) and Wolfe and Gacek (2001), mixing the varieties efficiently improves the control of diseases with an aerial dispersion phase, as in the case of the Cercospora agent. Burt et al. (1977) evaluated the dispersion of conidia and ascospores of *M. musicola* and *M. fijensis* at different heights in the banana plantations. Although a higher quantity of conidia was collected within plantations, there were no statistical differences to the values obtained when the conidia were collected in the air above the banana trees. This result indicates that conidia might also be associated with the dispersion agents at long distances, as already reported for ascospores (Meredith et al. 1973, Gauhl 1994).

It is worth emphasizing that banana leaf spot was not chemically controlled, to avoid a great increase in the number of infections in the second cycle. According to Lannou and Pope (2001), the genetic diversity of the pathogen population is higher in a mixture of varieties than in a single resistant variety. Besides, both virulent and nonvirulent spores are found. The third mechanism to reduce the diseases in mixtures is therefore the induction of resistance reactions against virulent races by non-pathogenic spores in tissues, as mentioned above.

Thus, the reduced severity from the first to the second cycle in Banana leaf spot might be due to the benefits of the mixture of the varieties, such as the host/pathogen interactions, that occur within variety mixtures, resulting in an increased yield stability as well as quality (Newton and Swanston 1999), resistance durability against some pathogens (Becker and Léon 1988), genetic and ecological interactions between plants (Finckh et al. 2000).

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Avaliação da severidade da Sigatoka amarela no sistema de interplantio em dois ciclos da bananeira Prata Anã

RESUMO - *A banana 'Prata Anã' é a cultivar mais plantada no norte Minas Gerais, Brasil. No entanto, ela apresenta susceptibilidade a diversos agentes patogênicos. Assim, o presente estudo foi realizado para avaliar a severidade da Sigatoka amarela na cultivar Prata Anã no primeiro e segundo ciclos em seis diferentes sistemas de plantio. O delineamento experimental foi em blocos casualizados com seis tratamentos e quatro repetições. As cultivares Thap Maeo e Caipira não apresentaram sintomas da doença, confirmando a resistência a Sigatoka amarela. A curva de evolução da doença apresentou efeito sazonal no primeiro e segundo ciclos. O maior grau de severidade da doença ocorreu logo após o período chuvoso que se estende de novembro a março na região. Ao comparar os resultados, a média dos graus de severidade indicou uma redução da doença do primeiro para o segundo ciclo.*

Palavras-chave: *Musa* sp., *Mycosphaerella musicola*, severidade da doença, interplantio.

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