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Article

Weed Interference on 'Prata-Anã' Banana Production

Interferência de Plantas Daninhas na Produção da Banana 'Prata-Anã'

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ABSTRACT - In the state of Minas Gerais, the northern region is one of the main banana production cores. Weed interference can reduce crop growth and, consequently, lead to reduced yield and fruit quality. Therefore, the objective of this study was to evaluate the interference of weeds in the production of the first and second cycles of 'Prata-Anã' bananas. The experimental design was randomized blocks, with ten treatments and three replicates, evaluated in two crop cycles. The treatments were ten periods of weed control, from planting: without control; control throughout the whole experimental period; control only in the first month after planting; control until the second; third; fourth; fifth; sixth; eighth and tenth months after planting. The agronomic and productive characteristics of the 'Prata-Anã' bananas were evaluated aton harvest. The maintenance of 'Prata-Anã' bananas without weed coexistence for up to 30 days after planting was enough to obtain fruits with satisfactory quality and productivity, both in the first and in the second production cycle, without altering the vegetative and reproductive cycles.

Keywords: *Musa* spp., competition, control.

RESUMO - No Estado de Minas Gerais, a região Norte constitui um dos principais núcleos de produção de banana. A interferência de plantas daninhas pode reduzir o crescimento da cultura e, consequentemente, levar à redução na produção e qualidade dos frutos. Portanto, objetivou-se com este estudo avaliar a interferência de plantas daninhas na produção do primeiro e segundo ciclos da bananeira 'Prata-Anã'. O delineamento experimental foi em blocos casualizados, com dez tratamentos e três repetições, avaliadas em dois ciclos de cultivo. Os tratamentos foram constituídos de dez períodos de controle das plantas daninhas a partir do plantio: sem controle; controle em todo o período experimental; controle apenas no primeiro mês após o plantio; controle até o segundo; terceiro; quarto; quinto; sexto; oitavo; e décimo mês após o plantio. Avaliaram-se na colheita características agronômicas e produtivas da bananeira 'Prata-Anã'. A manutenção da bananeira 'Prata-Anã' sem a convivência com plantas daninhas por até 30 dias após o plantio foi suficiente para obtenção de frutos com qualidade e produtividade satisfatória tanto no primeiro quanto no segundo ciclo de produção, sem alterar os ciclos vegetativos e reprodutivos.

Palavras-chave: *Musa* spp., competição, controle.

INTRODUCTION

Among the fruit species cultivated in the northern region of Minas Gerais, the banana is the most important from the point of view of planted area and generation of employment and income. In 2018, Minas Gerais stood out with

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about 51.7 thousand hectares planted, which produced 766.3 thousand tons, which corresponds to 11.4% of national production. The north of the state was responsible for 55% of this production (SEAPA, 2019). The 'Prata-Anã' stands out among the main banana cultivars, showing fruits similar to the Prata cultivar in shape, size, taste and transport resistance, with good shelf life and excellent commercial acceptability, as well as some advantages over the Prata, such as lower plant height and higher productivity (Silva et al., 2016).

The emergence of weeds presents one of the critical points in banana cultivation. Its occurrence during the conduction of the crop can generate a negative association, above all, of the competition for the essential elements of development, compromising the success in the production (Gomes et al., 2010). The crop plants can also be affected as a result of allelopathy, where weeds release substances that hinder or impede their growth (Arévalo et al., 2011).

According to Cordeiro (2005), in the early phase of crop growth, in the first five months, weed control is indicated so that banana growth is not affected. In addition, factors such as cultivar, spacing, seedling types and edaphoclimatic conditions may also influence. Therefore, proper management should be carried out from the planting/emergence phase, so that the crop does noton have the production affected by the weed community (Pitelli and Pitelli, 2008). In practice, weed control is made by hoeing or by the residual effect of herbicides applied in pre-emergence, incorporated pre-planting or in initial post-emergence.

It is noteworthy that the coexistence time between weeds and cultivated species is a function of three periods of interference (Brighenti et al., 2004) – the period prior to interference (PPI), the total period of interference prevention (TPIP) and the critical period of interference prevention (CPIP) – and corresponds to the difference between PPI and TPIP, being the phase in which control practices should be adopted to prevent crop yield losses (Evans et al., 2003; Agostinetto et al., 2008).

Information about weed interference in banana fields, especially when irrigated, is very scarce in the literature, besides the fact that weeds infer loss of productivity because of the competition. Thus, the objective of this study was to evaluate the interference of weeds on the production of the first and second cycles of irrigated 'Prata-Anã' bananas.

MATERIAL AND METHODS

The experiment was conducted in the municipality of Porteirinha-MG, located at 43°15'49,89" of latitude and 15°38'34" of longitude, and 530 m of altitude, in an eutrophic Red Latosol (Embrapa, 2013). The climate of the region, according to Köppen's classification, is Aw. The total rainfall in the experimental period, which corresponded to two years and seven months, was 1,475 mm, being distributed in 560.6 mm, 588.7 mm and 326.1 mm for each period of the evaluated years, respectively, with average temperatures. maximum 32 °C and average minimum 19 °C, insolation of 2,827 hours per year and average relative humidity of 65%.

Prior to the installation of the experiment, soil samples were collected at a depth of 0-20 cm, physically and chemically analyzed, presenting the following results: pH (in water) = 6.5; OM = 0.7 dag kg^{-1}; P = 8.5 mg dm^{-3}; K = 137 mg dm^{-3}; Ca^{+2} = 3.2 $cmol_c$ dm^{-3}; Mg = 0.8 $cmol_c$ dm^{-3}; SB = 4.6 $cmol_c$ dm^{-3}; t = 4.6 $cmol_c$ dm^{-3}; T = 5.6 $cmol_c$ dm^{-3}; V = 82%; sand = 58 dag kg^{-1}; silt = 27 dag kg^{-1}; clay = 15 dag kg^{-1}; textural class = franc-sandy.

The soil preparation for planting consisted of subsoiling, plowing, harrowing and furrowing. Planting of the "Prata-Anã" bananas was carried out using previously selected and cleaned sword suckers seedlings, eliminating the excess of roots, in the spacing of 3 x 2 m. The irrigation system used was the micro-sprinkler, applying a depth between 6 and 8 mm per day to maintain the water demand of the plants.

The 8 x 6 m plots consisted of three rows with five plants, totaling 15 plants, of which the three central plants were considered useful. After soil tillage, and as soon as weeds began to grow, weeds were counted using the square inventory method (1.0 m side), which was randomly thrown into the area eight times by zigzag walking, following the method of Braun-Blanquet (1979) and Erasmo et al. (2004). Weeds were identified and classified by family, genus and species. From these data the frequency, density, abundance and importance value index of the species present in the area were calculated. (Curtis and McIntossh, 1950; Odum, 1971; Braun-Blanquet, 1979).

Planting fertilization was done in the first year, before the crop was implanted, based on the interpretation of the results of soil analysis and mulching, following the recommendations of Silva and Borges (2008). Twice a year, foliar applications were made with sulfocalcium spray and commercial products based on plant hormones, phosphites and amino acids. In early summer and early winter, aerial applications were performed with triazole fungicides to control yellow sigatoka (*Micosphaerella musicola*).

The experimental design was in randomized blocks with three replications and ten treatments, which consisted of weed control periods, with the exclusive use of hoe from planting, and carried out in the first production cycle, being: without control (T1); control throughout the experimental period (T2); control only in the first month after planting (T3); control up to the second (T4); third (T5); fourth (T6); fifth (T7); sixth (T8); eighth (T9); and tenth month after planting (T10). The treatments were established only in the first cycle and in the whole area of the plot, since for the second year the crop was already shading the soil, in addition to the litter that covered the soil, preventing the establishment of weeds.

Assessments of agronomic characteristics were made in the first two cycles of banana production, the seasons were fixed from the point of view of plant phenology (bunch emission). The height of the plants at the time of bunch emergence was measured with a measuring tape, by the distance from the base of the pseudostem to the leaf rosette, at the time of insertion of the stem in the pseudostem. The number of days until flowering and until harvest was determined by the difference between the respective dates and the planting date. The days between flowering and harvest were determined by the difference between these dates. The individual weight of bunches, hands, and bunches with and without stems were determined using a mechanical scale and expressed in kg.

The hands were counted and recorded, considering the total number of hands per bunch. The number of fruits per hand and the total number of fruits were quantified. The external curvature length of the central fruits of the fifth hand was measured, in centimeters, using a measuring tape (cm), from the apex to the base (disregarding the pedicel and the apex of the fruit). The diameters of the central fruits of the fifth hand were measured in millimeters (mm) in the median region of the fruits lengthwise, with an analog caliper, positioning it on the sides of the fruits. The yields for the first and second cycle were estimated by multiplying the total weight of the bunches by the number of plants per hectare. Annual yields for the first and second cycle were obtained by dividing the yield of each cycle by the days until harvest and multiplying by 365 days. The accumulated productivity was obtained by summing the productivity of the first and second cycle.

The collected data were submitted to analysis of variance with the aid of the statistical program SAEG 5.0; when significance was observed by the F test, the means were grouped by the Scott-Knott test at a 5% probability level.

RESULTS AND DISCUSSION

The species that showed higher frequency indices and represented the distribution by area in the present study were: *Sida cordifolia*, *Senna obtusifolia*, *Mollugo verticillata* and *Dactyloctenium aegyptium*, with F = 1 (occurrence in all evaluated squares); *Ipomoea grandifolia*, with F = 0,9; and *Aeschynomene denticulata* and *Portulaca oleraceae*, with F = 0,8. For density, i.e., the number of plants per species per unit area, the main ones were: *Sida cordifolia* (53,5), *Dactyloctenium aegyptium* (14,6) and *Mollugo verticillata* (14,4). For abundance, which indicates the concentration of species in the area, the highest values were shown by *Sida cordifolia* (53,5), *Dactyloctenium aegyptium* (14,6), *Mollugo verticillata* (14,4) and *Sidastrum micranthum* (13).

The importance value indexes (IVI) of the species, which represent the sum of the relative frequency (Fr), density (Dr) and abundance (Ar) indexes, were: *Sida cordifolia* (102,19), *Dactyloctenium aegyptium* (36,46), *Mollugo verticillata* (36,16), *Senna obtusifolia* (24,96), *Sidastrum micranthum* (24,66), *Ipomoea grandifolia* (19,19), *Portulaca oleraceae* (18,25), *Aeschynomene denticulata* (11,32), *Amaranthus deflexus* (9,68) and *Crotalaria micans* (7,67). The predominance of weeds with C3 metabolism justifies that T2 (control throughout the experimental period) did not show any difference for T3 to T10 treatments (Tables 1, 2 and 3), since the experiment was carried out in an environment with high temperatures.

The periods from planting to flowering and planting to harvest for the first and second banana cycles were longer and significant for treatment without weed control when compared to the others (Table 1); the same was observed for the period from flowering to harvest in the first cycle.

Table 1 - Means of the period in days from planting to flowering (DTF), days to harvest (DTH), days from flowering to harvest (DFH) and length of central fruit of the 5th hand (LCF - cm), obtained for the first and second second productive cycles of Prata Anã bananas submitted to different weed control periods

Treatment	First cycle			Second cycle		
	DTF	DTH	DFH	DTF	DTH	LFC (cm)
1	366 a	529 a	168 a	646 a	790 a	15 b
2	212 b	350 b	138 b	465 b	625 b	17 a
3	230 b	366 b	137 b	520 b	692 b	17 a
4	206 b	341 b	136 b	461 b	625 b	17 a
5	206 b	341 b	136 b	495 b	657 b	16 a
6	212 b	346 b	134 b	448 b	589 b	16 a
7	207 b	345 b	138 b	468 b	630 b	17 a
8	217 b	347 b	130 b	457 b	611 b	18 a
9	213 b	347 b	134 b	440 b	616 b	17 a
10	224 b	352 b	128 b	469 b	632 b	16 a
CV (%)	6.07	3.32	5.82	10.10	8.30	7.11

Means followed by the same letter in the column belong to the same grouping by Scott-Knott test at a 5% level of significance. Treatments: without weed control (T1); control throughout the experimental period (T2); control only in the first month after planting (T3); control up to the second (T4); third (T5); fourth (T6); fifth (T7); sixth (T8); eighth (T9); and tenth month after planting (T10).

In the first production cycle, the absence of weed control (T1) prolonged the period between planting date and flowering by 154 days, compared to the treatment in which weed control was performed throughout the experimental period (T2). In the same situation, the total cycle (planting until harvest) was extended by 179 days (Table 1). Competition between weeds and banana trees still in the early stages of vegetative growth, when the plants began to emit new leaves and roots and were less aggressive, may justify the prolongation of the cycles. However, the maintenance of this competition throughout the evaluated period also contributed to this result.

For the second cycle, in which weed interference was also observed, the lack of weed control (T1) prolonged the beginning of flowering and harvesting by 181 and 165 days, respectively (Table 1). In both cycles, the values expressed by the treatment without weed control were higher and significant when compared to those found in the other treatments.

However, it is important to emphasize that this difference is due more to the delay observed in the first production cycle than in the second cycle, since the total value of days until the production of the second bunch was considered. This observation is reinforced by the absence of a significant effect of treatments on the number of days from flowering to harvest. This can be explained by the characteristics of the Prata Anã banana plant, which shows high vigor and architecture that favors soil shading, preventing weed growth.

According to Radosevich et al. (2007), weeds compete directly with crops for elements such as water, light, nutrients, space and carbon dioxide, in addition to the possibility of releasing substances with allelopathic effects. Weeds can also act as intermediate hosts for pests, diseases and nematodes. Thus, decreases in yield, as well as the delay in flowering and harvesting periods, caused by weeds, may be a consequence of competition for essential growth factors available in the environment, as has been observed in the banana plantations of the region. Souza et al. (2010) observed that banana cultivars intercropped with cowpea (*Vigna unguiculata* L.) exhibited a prolonged period between planting date and flowering, probably due to competition.

The plants of the treatments in which hoeings were performed (T2 to T10) resulted in an average cycle of 348 days (Table 1), not differing from each other, which corroborates the data of Silva et al. (2013), who studied the yield performance of 'Prata-Anã' banana under the edaphoclimatic conditions of Juazeiro-BA and found a period of 347 days until harvest in the first production cycle.

For the first and second production cycles, a cluster for fruit length was formed by the Scott-Knott test ($p<0.05$). Plants from non-weeded control showed the lowest fruit lengths compared to other treatments (Tables 1 and 2).

Table 2 - Means of the total number of hands (TNH), total number of fruits (TNF), length of the central fruit of the 5th hand (LCF), weight of the bunch with stems (BWS) and weight of the bunch without stems (BWOS) obtained in the first productive cycle of Prata Anã bananas submitted to different weed control periods

Treatment	TNH	TNF	LCF (cm)	BWS (kg)	BWOS (kg)
1	7 b	87 b	13 b	10.99 b	10.10 b
2	9 a	127 a	17 a	16.02 a	14.82 a
3	8 a	110 a	18 a	16.58 a	15.50 a
4	8 a	129 a	19 a	16.38 a	15.16 a
5	8 a	115 a	19 a	17.17 a	15.68 a
6	8 a	118 a	18 a	15.48 a	14.13 a
7	8 a	120 a	18 a	15.47 a	14.22 a
8	9 a	127 a	19 a	17.10 a	15.83 a
9	8 a	118 a	18 a	14.84 a	13.66 a
10	8 a	116 a	18 a	14.92 a	13.77 a
CV (%)	5.00	9.30	7.13	11.75	12.12

Means followed by the same letter in the column belong to the same grouping by Scott-Knott test at a 5% level of significance. Treatments: without weed control (T1); control throughout the experimental period (T2); control only in the first month after planting (T3); control up to the second (T4); third (T5); fourth (T6); fifth (T7); sixth (T8); eighth (T9); and tenth month after planting (T10).

Fruit length is generally used to classify the product into categories or classes. Fruits from 12 to 14 cm long are from the second category, fruits from 14 to 16 cm long fall into the first category, and those over 16 cm long are from the export category (Frutisséries, 2000). Thus, in the present study, fruits from plants without weed control for the first and second cycles do not fall into the export category, being situated only as second and first fruits, respectively, proving the negative effect of weed interference 30 days after planting.

The fruits of said treatment do not fall into the export category for classification of fruits and are classified only as first-class fruits.

There was no cluster formation by Scott-Knott test ($p>0.05$) for the first and second production cycle between treatments for the variables: weight of the hands, plant height at cluster emission, diameter of the central fruit of the fifth hand and stalk weight (data not shown). The averages observed for weight, in kg, from the first to the eighth hand were 2.25; 1.97; 1.86; 1.76; 1.71; 1.61; 1.43; and 1.29 kg, respectively, for the first cycle and 2.59; 2.38; 2.33; 2.10; 1.94; 1.95; 1.85; and 1.80 kg, respectively, for the second cycle; plant height at bunch emission, diameter of the central fruit of the fifth hand and stalk weight expressed averages of 2.55 m, 36 mm and 1.21 kg, respectively, for the first cycle, and 3.59 m, 37 mm and 1,36 kg for the second cycle. Therefore, the interference of weeds on the crop is noton harmful to the weight of the 1st to the 8th hand, justifying the similarity of the effects between the treatment without weed control and the others with increasing control periods.

Two groups were formed by the Scott-Knott criterion ($p<0.05$): the first was represented by the uncontrolled weed treatment (T1), with lower total number of hands and fruits, and the second involved the remaining treatments (T2 to T10). Treatment without weed control had a reduced number of fruits (87) when compared to the other treatments, which varied from 110 to 129 fruits per bunch (Table 2).

The weight of the bunch with and without stems was also reduced in the first cycle of plants without weed control, when compared to the other treatments, corroborating the negative effect of interference (Table 2). This behavior is linked to the condition of bunch growth in this treatment. The plants of the treatment without weeding presented smaller bunches, with fewer hands and fruits per hands and, consequently, lighter stems. Lighter and thinner stems support smaller and lighter fruits and hands (Donato et al., 2006), resulting in lower productivity.

Weed interference decreased in all treatments from the second month after planting, when crop practices such as thinning, sprout removal and others began. After harvesting the first cycle bunch, the plant residues, such as pseudostem, leaves and floral remains of the plants, remained in the area, serving as mulch and promoting nutrient cycling. The presence of these crop residues, besides acting as a physical barrier, reducing the emergence rate of weeds, improves soil fertility, providing nutritional support to banana. According to Souza and Resende (2003), this cover positively influences the physical, chemical and biological qualities of the soil, as well as the erosion reduction, creating optimal conditions for root growth.

In contrast, the number of fruits per hand for the first production cycle varied according to the different weed control periods (Table 3). The Scott-Knott test ($p<0.05$) allowed the formation of two clusters for fruit number per hand for hands 3, 4 and 5. The plants of the treatment without weed control showed less fruits per hand, compared to other treatments. In the second production cycle, there was no significant difference between treatments for number of fruits per hand. This evidenced the recovery capacity of the Prata Anã banana, which ensured the same number of fruits per hand, regardless of weed management. Similar fact was observed for the production in the same period.

Table 3 - Number of fruits of the hand 3 (NFH3), number of fruits of the hand 4 (NFH4), number of fruits of the hand 5 (NFH5), yield (Y1) and annual yield (Y2) obtained in the first production cycle of Prata-Anã bananas subjected to different weed control periods

Treatment	NFH3	NFH4	NFH5	Y1 (ton ha^{-1})	Y2 (ton ha^{-1} $year^{-1}$)
1	12 b	13 b	12 b	16.83 b	11.67 b
2	15 a	14 a	14 a	24.70 a	25.94 a
3	14 a	14 a	13 a	25.83 a	25.79 a
4	15 a	14 a	14 a	25.26 a	27.01 a
5	14 a	14 a	14 a	26.13 a	27.94 a
6	14 a	14 a	14 a	23.56 a	24.89 a
7	15 a	14 a	14 a	23.70 a	25.13 a
8	15 a	14 a	14 a	26.39 a	27.77 a
9	15 a	14 a	14 a	22.76 a	23.93 a
10	14 a	14 a	13 a	22.94 a	23.77 a
CV (%)	4.35	3.18	3.52	12.12	13.54

Means followed by the same letter in the column belong to the same grouping by Scott-Knott test at a 5% level of significance. Treatments: without weed control (T1); control throughout the experimental period (T2); control only in the first month after planting (T3); control up to the second (T4); third (T5); fourth (T6); fifth (T7); sixth (T8); eighth (T9); and tenth month after planting (T10).

The presence of weeds throughout the cycle resulted in a loss of approximately 8 ton ha^{-1} and 14 ton ha^{-1} $year^{-1}$ in yield and annual yield, respectively, for the first cycle (Table 3) when compared to the treatment with weed control throughout the cycle. This low yield obtained for the non-weeded treatment is associated with weed interference in the crop. Weeding treatments (T2 to T10) formed a superior grouping for yield. These yields are within the regional average (25 to 26 ton ha^{-1}) and well above the national average (14 ton ha^{-1}), according to IBGE (2014).

There was no grouping by the Scott-Knott test ($p>0.05$) between treatments for yield, annual yield and accumulated yield in the second production cycle, and these characteristics presented averages of 163 days, 31 ton ha^{-1}, 31.5 ton ha^{-1} $year^{-1}$ and 54.6 ton ha^{-1}, respectively. The same was observed for total number of hands, total number of fruits, diameter of the central fruit of the fifth bunch, plant height at bunch emission, bunch weight and bunch weight with stems and without stems in the second production cycle, with average values of 9 hands, 127 fruits, 38 mm, 3.6 m, 1.4 kg, 20 kg and 18.6 kg, respectively.

This indicates that the crop was able to partially overcome the competition with weeds that occurred initially, because of all the variables analyzed in the second cycle, only the length of the fruit and the period between planting and flowering and planting and harvesting were negatively affected by coexistence. In the second cycle, visually, the banana plants were already established and more vigorous compared to those of the first cycle, increasing shading, which reduced the density and occurrence of weeds in the area.

According to Cordeiro (2005), competition with weeds may imply a reduction in crop vigor, with the first five months of development being the moston harmful to the bananas. This information is also endorsed by Alves et al. (2016), who argue that in the first five months after planting the seedlings, the soil surface is exposed to direct light, and the weed control actions employed should ensure a competitive advantage for the bananas and preventon harmful effects of weed interference. However, the results of the present study, for the evaluated cultivation and cultivar conditions, indicate that the need for control goes until the first month after planting.

Among the resources disputed by banana and weeds, water deserves special mention, as it is a highly demanded resource by the crop (Coelho et al., 2006), and its scarcity in the semiarid region is evident (INMET, 2014). Even with the use of irrigation, small variations in water volume may be a limiting factor to the growth and development of the banana. According to Braga Filho et al. (2008), the phenological stages of greatest demand for water are the vegetative phases and from floral differentiation, justifying the damage caused to the crop by competition for this resource. However, competition seems to be more deleterious at the beginning of the banana's vegetative growth, since there are no structures, such as leaves and roots, which can reduce or inhibit the germination and, or, growth of weeds in the area. The results obtained in treatment 2 support this observation.

Most of the evaluated characteristics related to banana tree bunches were affected only in the first production cycle, presenting lower values when the system without weed control was compared with the other treatments. Thus, it can be inferred that the banana cultivation without weed control negatively interfered in the production components of 'Prata Anã' in its first cycle and that the banana plants, once established, became more competitive.

The results obtained in this work differ from the recommendations in the literature, which indicate that banana crop should be kept free of weed competition for up to six months after planting (Cordeiro, 2003). This difference can be explained by the vigor of the variety and seedlings used in the study. Horn-type seedlings have a reduced cycle and larger reserves when compared to micropropagated seedlings (Scarpare Filho et al., 1988; Teixeira and Bettiol Neto et al., 2011).

Additionally, the climatic conditions with high temperatures during the conduction of the present experiment, combined with the predominant plant species in the site, contribute to justify this result. For Karkanis et al. (2019), the effects of drought and temperature increase on weed competition are important on crop yields, as C4 metabolism weed species adapt better to these conditions compared to C3. C3 metabolism weeds were predominant in the area of this study; therefore, adaptation of cultivation systems according to environmental conditions is crucial to minimize the negative effects of invasive species.

As observed in the present study, the maintenance of the Prata Anã bananas without weed coexistence for up to 30 days after planting was sufficient to obtain fruits with satisfactory quality and yield in both the first and second production cycle, without changing the vegetative and reproductive cycles.

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