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PERFORMANCE OF 'NANICÃO JANGADA' BANANA PLANTS INTERCROPPED WITH WINTER COVER CROPS[1]

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ABSTRACT-The use of cover crops species may be an important strategy in the pursuit of sustainability of agroecosystems, considering benefits to soil, such as improvements of physical and chemical characteristics, and weed control. The objective of this study was to evaluate the effect of winter cover crops and other soil managements on chemical soil properties, on the cycle, on the production of the first cycle and on the fruit quality of banana cv. Nanicão Jangada in Andirá – PR, Brazil. The experiment was carried out in a commercial. Planting of banana suckers from the grower area occurred in the first half of March 2011, with a spacing of 2.40 m between rows and 1.90 m between plants. The experiment was designed in randomized blocks with four replications and six plants per plot. The six treatments were: black oat (*Avenastrigosa* Schreb), forage turnip (*Raphanus sativus* L. var. *oleiferus*), consortium of black oat and forage turnip, chicken litter, residues of banana plants, and bare ground. The evaluations were vegetative development and life cycle of banana plants, yield and quality of fruits, soil chemical characterstics, and fresh and dry mass of green manures. The results were submitted to ANOVA (F Test), and Tukey test at 5 % probability. Black oat and black oat with forage turnip consortium were superior in biomass production. Systems of soil management had no effect on the variables, except in the periods between planting and flowering and between planting and harvest, which were shorter in the treatment of soil management with crop residues, longer in the treatment with forage turnip, and intermediate in the other treatments.
Index terms: black oat, forage turnip, banana, green manure, banana plant cycle.

DESEMPENHO DE BANANEIRA'NANICÃO JANGADA' CONSORCIADA COM ADUBOS VERDES DE INVERNO

RESUMO-A adoção da prática da adubação verde pode significar uma estratégia importante na busca da sustentabilidade dos agroecossistemas pelos benefícios proporcionados ao solo, como melhoria das características físicas e químicas e controle de plantas invasoras. O objetivo deste trabalho foi avaliar o efeito do cultivo de plantas de cobertura de inverno em atributos químicos do solo, no ciclo, na produção de primeira safra e na qualidade dos frutos de bananeira cv. Nanicão Jangada, em Andirá-PR. O experimento foi realizado em pomar comercial e o plantio das bananeiras ocorreu na primeira quinzena de março de 2011, com espaçamento entre linhas de 2,40 m e de 1,90 m entre plantas, com mudas de rizomas da própria área do produtor. O experimento foi instalado em delineamento experimental de blocos ao acaso com quatro repetições e seis plantas úteis por parcela. Foram utilizados seis diferentes sistemas de manejo de solo: aveia preta (*Avena strigosa* Schreb), nabo forrageiro (*Raphanus sativus* L. var. *oleiferus*), consórcio aveia preta mais nabo forrageiro, cama de frango, restos culturais da bananeira e limpeza total da área. Foram realizadas avaliações de massa fresca e massa seca dos adubos verdes; ciclo e características vegetativas da bananeira, produção e qualidade dos frutos e características químicas do solo. Os dados foram submetidos à análise de variância (teste F) e, quando significativos, as médias foram comparadas pelo teste de Tukey a 5% de probabilidade. Não se observou efeito dos tratamentos sobre a produtividade e a qualidade da banana, e nem sobre os atributos químicos do solo. A aveia preta e aveia preta mais nabo forrageiro foram superiores em produção de massa fresca. Os tratamentos exerceram influência sobre o ciclo da bananeira. Os períodos entre o plantio e o florescimento e entre o plantio e a colheita foram mais curtos no tratamento da cobertura do solo com restos culturais da bananeira e mais longos com o tratamento de nabo forrageiro, e intermediários nos demais tratamentos.
Termos para indexação: aveia preta, nabo forrageiro, banana, adubação verde, ciclo da bananeira.

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INTRODUCTION

Banana is the most consumed fruit in the world. Its bark is easy to remove, hygienic and therefore practice to the customs. The lack of juice in the pulp, the absence of hard seeds, its nutritional value and availability in the Brazilian market and other countries throughout the year contribute also to its high consumption (Lichtemberg, 2007).

According to United Nations data for Food and Agriculture (FAO), India is the largest producer of banana (FAO, 2013), and Brazil ranks fifth in the ranking with 485,075 ha of area, and production of 6,892,622 t in the 2013 harvest (IBGE, 2015). The leading states in the Brazilian production of banana were in order: São Paulo, Bahia, Santa Catarina, Minas Gerais, Pará and Ceará (IBGE, 2013). In Paraná, which occupies the 8th place in the Brazilian production stands out the metropolitan region of Curitiba, with over 56% of the state production, and Pioneer North, which represents 28% of production (SEAB, 2013).

The reduction of yield with time in banana plantations is common as a consequence, in medium and long term, of physical and chemical limitations of soil and the rapid degradation of the root system by the action of phytosanitary problems in the soil, such as nematodes and fungi (DOREL, 1993). Because of these limitations, several initiatives are being studied to minimize the agronomic and environmental losses, highlighting the improvement and genetic modification in some crops, and also the use of cover crops (Silva et al. , 2006).

Cover crops or green manure is a technique that consists of planting native or introduced species, grown in rotation or intercropping with the economic interesting crop. These species may be of annual cycle, semi-perennial or perennial and can cover the ground for a few months or throughout the year. After its cutting, they can be incorporated into or maintained in the soil surface (ESPINDOLA et al., 2004).

Leguminous cover crops can provide benefits to the soil, with improvements in physical and chemical characteristics such as aggregation (PERIN et al., 2002), dry matter input (OLIVEIRA; GOSCH, 2007), providing N by biological fixation (GAMA-RODRIGUES et al., 2007), soil moisture maintenance, decrease in maximum temperatures and temperature range (TORRES et al., 2006), permanent protection against the main causative agents of soil degradation (LEITE et al., 2010) and control weeds (Silva et al., 2009).

For the consortium with banana trees, there are several desirable characteristics to a cover crop: production of viable seeds, good adaptation to soil and climatic conditions, ease of management, resistance to pests and diseases, good competition with weeds, shade tolerance and compatibility with the banana crop (Borges et al., 1997). The identification of green manure species adapted to soil and climatic conditions of each region is essential to ensure the success of the use of these plants. In recent years the studies regarding the behavior of green manures in banana crop were intensified (PERIN et al., 2009); however, information on this practice in Parana conditions are scarce.

The aim of this research work was to evaluate the effect of growing winter cover crops on soil chemical properties, and on the plant life cycle, on the yield of first crop and on the quality of 'Nanicão Jangada' banana fruits grow in Andirá, Pioneer Northern Paraná State, Brazil.

MATERIAL AND METHODS

The experiment was carried out in a commercial plantation in the county of Andirá-PR, with coordinates 22º 58 '40 "S, 50 ° 18' 52" E, altitude 380 m, from February 2011 to February 2013. The region has temperature annual average of 21.2 ° C and rainfall of 1,375 mm concentrated between October and March (Table 1); and relative humidity around 70% (IAPAR, 2014). The climate is Cfa, humid subtropical with hot summers, according to Köppen. The soil of the experimental area is an Oxisol, with medium texture and the slope from 0 to 3% (Santos et al., 2013) .

The experiment was established in a commercial area, and the previous five years had 'Maçã 'banana crop, and in the last eight months it was left bare ground. Before the banana planting, samples of soil were taken at 0-20 cm depth for chemical analysis, which revealed the following values: pH in $CaCl_2$, 5.3; organic matter, 21.5 g dm^{-3}; phosphorus, 9.9 mg dm^{-3}; potassium, 7.1 mmol dm^{-3}; calcium, 44 mmol dm^{-3}; and magnesium, 11.4 mmol dm^{-3}; and base saturation corrected to 70% with the application of 2 t ha^{-1} of limestone.

Banana trees were manually plated in the first half of March 2011, at 2.40 m spacing (lines) x 1.90 m (between plants), applying 200 g termofostato Yoorin® per hole. After 210 and 240 days from planting 150 g Sulfammo® per hole was applied; at this last application, it was added 180 g of potassium chloride per hole. To control diseases, Opera® fungicides were used (1.0 L h^{-1}), Impact® (0.5 L h^{-1}) and Nativo® (0.6 L h^{-1}) at 240, 270 and

300 days after planting, respectively, together with mineral oil (8.0 L h^{-1}).

‘Nanicão Jangada’ banana suckers were obtained from the own area of the producer, without chemical treatment. The suckers were prepared by cleaning, which consisted of cutting pseudostems and dismemberment of many rhizomes, removing the adhered soil and roots with a machete. After this, the rhizome dark tissues (cortex) were removed. The above ground part of plants were cut, leaving approximately 10 cm.

The banana plantation was carried out without irrigation and suckers were pruned leaving one follower by generation (BORGES; MATOS, 2006). All other crop managements were carried out when necessary according to the recommendations for the banana crop (Silva et al., 2004).

The experiment was conducted in randomized blocks design with plots consisting of three lines of 15 m long, with eight plants per row. Six plants at the centerline were considered useful plants for evaluating, discarding the first and the last plant. Six different soil cover systems were used: a) black oat cv. IAPAR 61 Ibiporã (*Avena strigosa* Schreb) between the lines of banana with seeding rate of 60 seeds per linear meter, with spacing of 20 cm between rows and 50 away cm from banana trees; b) forage turnip cv. IPR 116 (*Raphanus sativus* L. var oleiferus) between the lines of banana with seeding rate of 12 kg ha^{-1} of seeds using spacing of 20 cm between rows and 50 cm away from the banana trees; c) consortium of black oat ‘IAPAR 61 Ibiporã’ and forage turnip ‘IPR 116’ between the lines banana plants with 8 kg ha^{-1} of turnip seeds and 40 oat seeds of s per linear meter with spacing of 20 cm between rows and 50 cm away from the banana trees; d) 5 t ha^{-1} poultry litter (2.52% N, 1.44% Ca, 0.93% P and pH 8.61) applied between rows, and 50 cm away from the banana trees; e) ground cover of residues of banana crop and weeds between rows, collected during the whole cycle; f) bare ground, with cleaning up the area every two weeks, with the help of a hoe, removing all crop residues and weeds. Sowing of green manures was carried out manually, with seeds from the Agronomic Institute of Paraná (IAPAR) on May 17, 2011, the same date of application of poultry litter.

In the phase of full flowering of green manures (115, 117 and 121 days after planting, for oats, forage turnip and consortium, respectively) the plants were cut with a sickle close to soil surface keeping the plant residues covering the soil. The input of fresh and dry organic materials was evaluated by collecting two samples of 1 m^2 in each plot, throwing up a frame of this size randomly. The plants that were within this area were cut close to the soil surface, and the collected mass was weighed for calculation of fresh mass (kg ha^{-1}) and was subsequently packed in paper bags and brought to a forced ventilation oven at a temperature of 65 ° C until constant weight. After drying, the material was weighed on a digital scale with a precision of 0.1 g to calculate the mass of dry matter input (kg ha^{-1}).

At the beginning of banana trees flowering (appearance of the first bunch of inflorescence) the following parameters were evaluated: pseudostem height (cm); pseudostem perimeter (cm) at 30 cm from the ground; number of living leaves (approximately 50% of green leaf); and number of days from planting to flowering.

The harvest of banana bunchs was carried out when the fruits reached 38-40 mm in diameter, and the following parameters were evaluated: number of days from planting to harvest; number of days from the flowering to harvest; fresh mass of stem, hands, and whole bunch (kg); yield, calculated considering the mass of hands on a stand of 2,193 plants ha^{-1}; number of hands and fruits per bunch; fresh mass of the second hand (kg); fresh fruit mass (g), fruit length (cm), determined at the central fruit of the outer row of fruits on the second hand (DONATO et al., 2006).

After banana harvest, eight soil subsamples were collected at different points distributed throughout the area of each plot, with a soil auger with 9.0 cm in diameter at 0-20 cm depth, cleanning up the soil surface, removing leaves and other debris. The individual sub-samples from each plot were mixed to obtain a 500 g final sample that was wrapped in a plastic bag and sent to the Soil Laboratory of Faculdade Integrada de Ourinhos-SP, to evaluate the soil chemical properties according to Raij and Quaggio (1983): organic matter (g dm^{-3}); Phosphorus (mg dm^{-3}) by the method of resin; Potassium (mmol dm^{-3}); calcium (mmol dm^{-3}) and magnesium (mmol dm^{-3}).

The data were submitted to analysis of variance by F test and, when significant, the means were compared by Tukey test at 5% probability using the software Genes (Cruz, 2013).

RESULTS AND DISCUSSION

Regarding the production of fresh mass (Table 2), there were differences between the cover crops; the turnip (24,612 kg ha^{-1}), and the oat and turnip consortium (21,987 kg ha^{-1}) were superior to black oat (12,327 kg ha^{-1}). For dry matter (Table 2) there were no differences, ranging from 2,269 kg ha^{-1} for oats to 4,200 kg ha^{-1} for turnip. These values are higher than those found by Schoffel et al. (2011), that in an experiment carried oui in an Oxisoil in Cruz Alta-RS, obtained values of 1,230.00 and 1,282.72 kg ha-¹ for fresh mass and 292.20 and 330.12 kg ha-¹ for the dry matter of oat and turnip, respectively; this is due to the authors, probably to late sowing, low germination and not suitable conditions for the development of these species, because that region had low levels of rainfall in the emergency period and in the beginning of vegetative growth.

On the other hand, the values achieved in this study were lower than those obtained by Silva et al. (2007) in Eldorado do Sul-RS in an Hapludalf soil, where they obtained 3,600; 4,700; and 5,900 kg ha-¹ of dry matter for oats, oat and turnip consortium, and radish, respectively. This was possibly because the amount of available water in the soil have been kept close to field capacity by irrigation in that study, which did not occur in our experiment, and because the winter in our region is normally dry. At the time the cover plants were in the field (May, June and July 2011) there was low rainfall, with volumes of 4.9; 49.8; and 30.7 mm respectively (Table 1).

According to Teodoro et al. (2011), a major agronomic property used to evaluate green manure species is the production of fresh and dried masses. Espíndola (2001) reports that the supply of biomass and decomposition of debris from green manures can be a source of carbon and nutrients to the soil biota and, eventually, to the plants, highlighting the importance of synchronization between the release of nutrients by plants in consortium and its demand for major crops. In addition, factors such as the time of sowing and the environment (especially water supply) interfere in both the vegetative production, and in nutrient concentration of cover crops, promoting variations in the poduction within the same species (ALCÂNTARA et al., 2000) .

For the development of banana trees in this study, it was found that the plant height at flowering was not affected by the different soil cover systems, ranging between 209.33 cm when the area was clean up and 216.12 cm, when using turnip as ground cover (Table 3). The lack of effect of cover crops for this variable may be related to good conditions of soil fertility.

Unlike that observed in the present experiment, Barbosa et al. (2013), working with banana cv. Prata Anã in Pentecoste - CE with different irrigation levels, observed that the height of the plants in the treatment of conventional management of weeds exceeded intercropped with tropical kudzu and calopogonium, and the plants intercropped with spontaneous vegetation had significantly lower height than the others.

Also, in sudies done by Espindola et al. (2006), and Perin et al. (2009), in Seropédica - RJ, soil cover with forage peanut, tropical kudzu and siratro caused an increase in the height of banana trees when compared with treatments with spontaneous vegetation (both with and without nitrogen fertilization).

The height from 209.33 to 216.12 cm of banana plants cv. Nanicão Jangada in the flowering stage (Table 3) agrees with data observed for the same cultivar in other studies, such as Zonetti et al. (2003), in Ilha Solteira - SP, that found 240.0 cm and Camolesi et al. (2012b) in Assis - SP, with 193.0 cm. Plant height is an important character in banana crop, for influencing planting density, management, and consequently yield (ALVES; OLIVEIRA, 1999). Santos et al. (2006) point out that in a commercial farming it is not desirable having high plants, as these plants are difficult to harvest, in addition to favoring the overturning of the plant in case of strong winds or attacks of nematodes and borers.

The average pseudostem perimeter is also one of the important characteristics for the crop as it is associated with the vigor of the plant, the planting density and the capacity of carrying the bunch, especially for genotypes of greater height (Silva et al., 2002). For this parameter (Table 3) there were no differences among treatments. The observed values ranged from 51.62 cm, when it was used the banana crop debris as ground cover up to 54.79 cm when we used the turnip. These results are similar to those found by Ichikawa et al. (2012), in an experiment in Palmas - TO, in which no differences were obseerved among the three treatments used as ground cover in consortium with banana cv. Thap Maeo. The values determined in this study are in agreement with Camolesi et al. (2012b), who obtained perimeter of 57 cm for the same cultivar in the first production cycle in Assis - SP.

For the number of leaves in the beginning of flowering (Table 3), we found from 12.71 to 13.54 leaves, with no statistical difference among treatments. The number of active leaves in flowering is important because the generation of assimilates which influence directly the plant growth and production (ALVES; OLIVEIRA, 1999). In the study of Camolesi et al. (2012a) the number of leaves in the flowering of 'Nanicão Jangada' banana plants was 11.2 in Palmital-SP.

The vegetative cycle of the crop, ie, the period from planting to flowering varied in this work from 386.33 days for treatment with crop residues, to 431.50 days for treatment with forage turnip (Table

4), the first significantly lower than the treatments forage turnip and bare ground. This was probably because the cover crop residues provided a better ground cover, promoting water saving in the system when compared to treatments with lower capacity of soil physical protection.

For the period between flowering and harvest (Table 4), there was no difference among the treatments, ranging from 169.37 days to soil cover with banana crop residues to 188.95 days when using the oat and turnip consortium. Other studies have also shown that this period of the banana plant cycle suffers less influence from the environmental factors than the vegetative period (VICENTINI et al., 1996), since once initiated the cluster formation process, it is completed, and this is strongly influenced by the genotype (Lima et al., 2005).

For the number of days from planting to harvest there were differences among treatments (Table 4), and the oat and turnip consortium treatment provided the later harvest, with 611.87 days; whereas treatment with the banana crop residues led 555.70 days to harvest as a result of the difference observed during the vegetative part of the cycle. Espindola et al. (2006) observed higher early in the treatments in which they used forage peanut, tropical kudzu and siratro, approximately 600 days from planting to harvest, compared to soil covered with spontaneous vegetation, with 780 days. On the other hand, Paula (2008) did not observe differences in the time of harvest in the first production cycle in banana trees intercropped with three different species, *Acacia angustissima*, Gliricidia and tropical kudzu, in Seropédica - RJ.

Zonetti et al. (2003) in a study in Ilha Solteira - SP observed that the period from planting to harvest banana ‘Nanicão Jangada’ plants was 453 days for the first production cycle, lower than we observed in this study, probably due to the warmer climate, because in that region the average annual temperature is around 24,1°C. The precocity of the crop is a desirable feature for growers faster return of investments (Silva et al., 2001).

For the mass values of the bunch, stem, hands and of the second hand (Table 5), it is observed that there were no differences between treatments, with values up to 17.63 from 18.90 kg for bunch mass; 1.13 to 1.25 kg for the mass of stem, 16.44 to 17.67 kg for the mass of hands and 3.00 to 3.37 for the mass of the second hand. Also Paula (2008) did not observe differences in the mass of banana cv. Prata bunchs, intercropped with three different cover crops (*Acacia angustissima*, Gliricidia and tropical kudzu) in Seropédica-RJ.

Barbosa et al. (2013), unlike we observed in this study, noted that the conventional management with nitrogen fertilization and without cover crops, using different irrigation levels, provided greater mass of bunches and mass of hands than the treatments with cover crops of tropical kudzu, and calopogonium in the first production cycle banana cv. Prata Anã.

Moreover, Perin et al. (2009) observed that the mass of hands and bunches of second cycle of banana ‘Nanicão’ was positively influenced by the cover crops of tropical kudzu and siratro compared with spontaneous vegetation. Espindola et al. (2006) also observed that the soil cover with tropical kudzu and siratro provided increases in the yield, in the mass of hands and bunches, and in the number of fruits per hand on the first crop of banana plants cv. Nanicão when compared to spontaneous vegetation.

Unfavorable climate conditions can cause reductions in the mass of bunches of banana trees intercropped with perennial cover crops, as reported by Johns (1994) for banana plants with *Arachis pintoi* in Australia. One of the possible causes of these results is the competition for water between the cover and banana crops, because the yield gap between irrigated and non-irrigated banana crops can reach 200% depending on location conditions (MANICA, 1998). Although there was no effect of treatments for the production variables in this study, the experiment went through periods of unfavorable weather conditions, as it was not irrigated and rainfall in the region were irregular and atypical, with values below the indications of 100 mm monthly by Moreira (1999), from March to September 2011, February, March, May, July, August and September 2012 (Table 1).

Nevertheless, the bunches obtained in this study were similar in mass to those observed by Camolesi et al. (2012a) for the same cultivar, when assessing the banana production characteristics of banan cv. Nanicão Jangada in Palmital - SP, obtaining 17.60 kg for bunch mass, 1.28 kg for the mass of the stem, 16.32 kg for mass of hands, but those authors found lower value for mass of the second hand, with 2.46 kg, which is one of the factors related to fruit quality (SOTO BALLESTERO, 1992).

When analyzing the number of hands per bunch, number of fruits per bunch and yield (Table 6), there were no differences among soil management systems. But Perin et al. (2009), in a Paleudalf soil in Rio de Janeiro with fertility similar to the soil of our study, obtained variation from 5.88 to 6.92 hands per bunch for forage peanut, tropical kudzu and siratro intercropped with banana cv. Nanicão, being statistically superior to spontaneous vegetation (4.25 hands per bunch).

Also, Barbosa et al. (2013), in Ceará, using banana cv. Prata Anã intercropped with tropical kudzu and calopogonium, had a significant increase in the number of hands (9 per bunch) when used the conventional management (without cover crops) compared to treatments with cover crops, which produced between 7 and 8 hands per bunch.

For yield, the results of this study support the work done by Flori et al. (2011) who did not find any significant differences using four leguminous cover crops intercropped with banana cv. Nanicão in semi-arid conditions, with an average of 35 t ha^{-1}; and the experiment of Paula (2008), that had no differences using *Acacia angustissima*, Gliricidia and tropical kudzu with banana cv. Prata in Rio de Janeiro. Unlike that, Barbosa et al. (2013) in the first production cycle of banana cv. Prata Anã in Ceará had higher number of fruits per bunch (139 fruits) and productivity (29.34 t ha-1) when they used the conventional management without cover crops, compared with the managements with tropical kudzu and calopogonium. Also, Espindola et al. (2006) in the first production cycle of banana cv. Nanicão observed both the number of fruits and yield were higher in treatments that used the cover crops forage peanut, kudzu tropical and siratro.

Regarding the mass and the length of fruit, no differences were detected as a result of the treatments (Table 6). The mass ranged between 205 and 220 g, while the length was from 22.01 to 22.93 cm. These results were similar to those obtained by Paula (2008) in Seropédica - RJ, that had no differences in the length of the fruits of banana trees cv. Prata intercropped with *Acacia angustissima*, Gliricidia, kudzu tropical and spontaneous vegetation.

Camolesi et al. (2012b), in an experiment in Assis - SP with the same cultivar Nanicão Jangada observed similar values compared with our research work for the fruit length (22.32 cm), but lower values for the fruit mass (176 g). Camolesi et al. (2012a) also for bananas cv. Nanicão Jangada observed 21.42 cm for length and 149 g for the mass of fruit in Palmital - SP. The values observed in different studies may be related to soil and climatic variations and also to the setting of harvest time.

For soil chemical properties (Table 7), it is observed that only the phosphorus content had differences among treatments, being the use of poultry litter higher than the other treatments. According to Paula (2008), the deposition of organic matter from cover crops may not be sufficient to provide the essential elements for the banana crop. Furthermore, the deposition time may also not have been enough to raise the amount of nutrients in the soil thus according to Espindola et al. (1997), one should not expect immediate answers, since the benefits from the addition of crop residues to the soil are more significant in the medium and long term. Faria et al. (2007) in Petrolina - PE with the melon crop, observed that these positive influence on soil chemical properties were significant only after three cycles with cover crops. Flori et al. (2011) pointed out that it is expected that the benefits of green manures occur from the second year of cultivation. However, it is important to note that from the second year the banana trees provide shade between the lines and it is important to assess less demanding light cover crops species.

David et al. (2008) consider that the increase in phosphorus content, when using poultry litter is due to factors such as the extra supply of carbon to the activity of mycorrhiza, and organic acids to solubilize the inorganic phosphorus. Thus, the addition of poultry litter, besides contributing to the addition of phosphorus to the soil, reduces its immobilization, and also improves P utilization efficiency arising from fertilizers. According to Correa and Miele (2011), with the application of poultry litter in the correct way and for long periods, we can observe the occurrence of improvement in soil properties, and most of these benefits ares attributed to organic matter, which influences all soil properties, such as cation exchange capacity; availability and cycling of nutrients for crops; complexation of nitrogen and other nutrients, making them available to plants gradually while avoiding the fixation of phosphorus to sesquioxides of iron and aluminum in the soil; bulk density; porosity, the rate of infiltration and retention of air and water.

However, Santos et al. (2001) observed that in the recovery of degraded areas using legumes and grasses, the contents of K, organic matter and Mg were higher when compared to the control without any coverage. The difference between those results and the present study is explained by the fact that Santos et al. (2001) performed the study in degraded areas, with very low initial levels of nutrients, unlike the history of this work area, which had been maintained with banana crop and fertilized according to the recommendations.

TABLE 1- Monthly rainfall precipitations (in mm) during the years of the study in Andirá - PR.

Month	Year 2011	Year 2012	Year 2013
	Precipitation (mm)		
January	234.7	247.9	88.4
February	147.4	72.6	268.6
March	54.1	78.7	144.2
April	62.3	121.8	282.8
May	4.9	84.0	170.7
June	49.8	342.2	149.3
July	30.7	64.8	54.2
August	51.1	0.0	0.0
September	0.0	67.5	121.9
October	346.2	150.9	180.5
November	91.2	108.4	49.7
December	113.1	202.5	21.5
Total	1,185.5	1,541.3	1,531.8

Source: ÁGUAS DO PARANÁ, 2014.

TABLE 2 - Mass production of fresh and dry matter (kg ha^{-1}) of above ground parts of plants of winter cover crops used in the plantation of banana cv. Nanicão Jangada, Andirá PR-2012.

Green manure	Fresh matter mass (kg ha^{-1})	Dry matter mass (kg ha^{-1})
Black oat (BO)	12,327 b*	2,269 a
Forage turnip (FT)	24,612 a	4,200 a
Consortium BO+FT	21,987 a	3,300 a
VC (%)	22.40	53.33

* Means followed by the same letter in the column do not differ significantly by Tukey test at 5% significance level.

TABLE 3 - Plant height (cm), pseudostem perimeter (cm) and number of leaves at flowering (NLF) of banana plants cv. Nanicão Jangada subjected to soil management treatments. Andirá PR-2012.

Treatments	Plant height (cm)	Pseudostem perimeter (cm)	NLF
Poultry litter	214.17a*	54.50a	13.04a
Black oat (BO)	211.88a	52.87a	13.08a
Forage turnip (FT)	216.12a	54.79a	13.54a
Consortium BO+FT	215.38a	54.04a	12.91a
Crop residues	213.63a	51.62a	12.71a
Bare ground	209.33a	52.50a	13.54a
Mean	213.41	53.38	13.13
VC(%)	5.94	7.36	4.85

* Means followed by the same letter in the column do not differ significantly by Tukey test at 5% significance level.

TABLE 4 - Number of days from planting to start of flowering (DPF), from the start of flowering to harvest (DFH) and from planting to harvest (DPH) of banana cv. Nanicão Jangada subjected to soil management treatments. Andirá PR-2012.

Treatments	DPF	DFH	DPH
Poultry litter	402.87ab*	172.25a	575.12ab
Black oat (BO)	400.33ab	174.54a	574.87ab
Forage turnip (FT)	431.50b	180.37a	611.87a
Consortium BO+FT	417.16ab	188.95a	606.12ab
Crop residues	386.33a	169.37a	555.70b
Bare ground	402.00ab	169.95a	571.95ab
Mean	406.69	175.90	582.60
VC (%)	4.77	8.48	3.84

* Means followed by the same letter in the column do not differ significantly by Tukey test at 5% significance level.

TABLE 5 - Bunch mass (kg), stem mass (kg), mass of hands (kg) and mass of the second hand (kg) of banana cv. Nanicão Jangada plants subjected to soil management treatments. Andirá PR-2012.

Treatments	Bunch mass (kg)	Stem mass (kg)	Mass of hands (kg)	Mass of the 2nd hand (kg)
Poultry litter	17.92a*	1.13a	16.80a	3.06a*
Black oat (BO)	18.53a	1.25a	17.27a	3.37a
Forage turnip (FT)	17.63a	1.18a	16.44a	3.00a
Consortium BO+FT	18.47a	1.23a	17.23a	3.16a
Crop residues	18.90a	1.23a	17.67a	3.15a
Bare ground	18.44a	1.16a	17.28a	3.18a
Mean	18.31	1.19	17.11	3.15
CV(%)	17.53	15.83	17.73	14.86

* Means followed by the same letter in the column do not differ significantly by Tukey test at 5% significance level.

TABLE 6 - Number of hands per bunch, number of fruits per bunch, yield (kg ha^{-1}), mass (g) and length (cm) of the fruit of banana cv. Nanicão Jangada plants subjected to soil management treatments. Andirá PR-2012.

Treatments	Number of hands	Number of fruits	Yield (t ha^{-1})	Fruit mass (g)	Fruit length (cm)
Poultry litter	6.54a*	88.79a	36.841a	207a*	22.30a
Black oat (BO)	6.71a	94.91a	37.888a	210a	22.93a
Forage turnip (FT)	6.63a	89.12a	36.070a	220a	22.25a
Consortium BO+FT	6.91a	98.75a	37.796a	205a	22.01a
Crop residues	6.46a	95.71a	38.758a	207a	22.62a
Bare ground	6.58a	94.71a	37.895a	205a	22.39a
Mean	6.63	93.66	37.541	209	22.41
CV(%)	10.99	15.73	17.73	7.90	3.12

* Means followed by the same letter in the column do not differ significantly by Tukey test at 5% significance level.

TABLE 7 – Contents of soil organic matter (OM), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg) on 0-20 cm layer of soil cultivated with banana cv. Nanicão Jangada subjected to soil management treatments . Andirá PR-2012.

Treatments	MO g dm^{-3}	P mg dm^{-3}	K	Ca	Mg
				$mmol_c dm^{-3}$	
Poultry litter	23.35a*	74.91a	5.07a	62.30a	15.20a
Black oat (BO)	22.44a	21.68b	5.29a	44.52a	14.37a
Forage turnip (FT)	21.45a	13.74b	5.73a	37.14a	11.58a
Consortium BO+FT	21.45a	23.74b	6.11a	35.56a	10.99a
Crop residues	20.46a	20.54b	6.66a	38.85a	12.76a
Bare ground	20.54a	14.97b	5.11a	45.58a	13.77a
Mean	21.61	28.26	5.66	43.99	13.11
CV (%)	7.88	56.44	58.67	26.47	25.92

* Means followed by the same letter in the column do not differ significantly by Tukey test at 5% significance level.

CONCLUSIONS

Soil management systems have no effect on the yield and quality of banana cv. Nanicão Jangada in Pioneer Northern Paraná State.

The periods between planting and flowering and between planting and harvesting of bananas are shorter when using covering the soil with residues of banana crop and of weeds between rows, and longer with forage turnip as cover crop.

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