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Fertilization with poultry litter in a corn crop for silage

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The increase in broiler production in Brazil has increased the production of poultry litter. Thus, the management and adequate disposal of this waste is recommended. Agricultural use is a promising solution. This study evaluated the productivity of corn for silage with different fertilizations of poultry litter. The production of Dry Matter (DM), Crude Protein (CP), Ether Extract (EE), Mineral Matter (MM) and Organic Matter (OM), and microbial activity of the soil such as Microbial Biomass Carbon (MBC), Metabolic Quotient (qCO_2) and Microbial Quotient (*q*MIC), were evaluated. There were treatments composed of a control that received mineral fertilization (33 Kg N, 80 Kg P_2O_5 and 80 Kg K_2O) and treatments with poultry litter Rice Straw (RS) and Wood Shavings (WSH) (doses of 2.5; 5.0; 7.5 and 10.0 Mg ha^{-1}). The treatments with poultry litter received, at sowing, 1/3 of the mineral fertilization. The evaluation of the production of corn for silage was carried out in the R4-R5 phase, and soils collected in the 0 to 10 cm layer in the post-poultry litter (A) and post-herbicide (B) periods. The microbial communities were influenced by anthropic activity in every treatment, with fall in MBC and the significant increase in the qCO_2 in the control and the *q*MIC in the treatments that received poultry litter, demonstrating greater efficiency in mineralization of nutrients. As regards DM productivity, there was no difference in the treatments; however, treatments 7.5 RS and 10 WSH presented higher levels of protein and ether extract similar to the control treatment. This study concluded that the treatments with poultry litter favored the use of soil OM, which had less impact on microbial activity, and proposed that the substitution of 2/3 of the fertilization would not cause losses or decrease in the production or characteristics of the corn silage.

Key words: *Zea mays*, organic fertilization, organic matter and poultry waste.

INTRODUCTION

Exponential population growth demands more food, and to satisfy this necessity, larger quantities of wastes are produced that, if not managed correctly, pollute the air, water and soil. Thus, the inclusion of the concept of

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sustainability and environmental management become important factors in current agricultural and cattle-raising activities (Costa et al., 2014).

The search for sustainable development represents one of the greatest challenges facing humanity. Brazil, the third largest producer of chicken in the world in 2013, produced 12,308 million tons, with the state of Paraná responsible for 29.4% of the national carcass slaughter (UBABEF, 2014). According to Marín (2011), the mean final waste production of poultry litter is 2.2 kg per broiler unit. Studies show that the litter can be reused 1 to 6 times without significant differences as regards mortality, weight gain, feed intake, feed efficiency and quality of the carcasses, demonstrating some beneficial properties for flocks with acquired immunity (Fukayama, 2008).

Current poultry exploitation is characterized by the production of precocial chickens. This development is anchored in the advances of genetics, nutrition, health and management. The increasing production of chickens leads to larger quantities of poultry litter (UBABEF, 2014). According to Costa et al. (2009), poultry litter is a material rich in nutrients and, thanks to its low-cost availability, is included in the fertilization of commercial cultures.

Due to these characteristics, poultry litter is being employed in the fertilization of large cultures like corn (*Zea mays* L.), which is one of the main cereals cultivated and consumed worldwide (Bobato, 2006). Known for its versatility of use, social aspect and consequence of human and animal production, the need to increase the productivity of the culture per planted area has produced an increase in the consumption of this product. In the 2012/2013 harvest, Brazil produced 77.887 million tons of corn, occupying an area of 15,726.3 thousand hectares (CONAB, 2014). This ingredient is also traditionally the material that is used the most for silage, due to its high yield potential in the production of mass and its bromatological quality, confirming the production of good silage (Ferreira, 2001).

Corn for silage requires special care as regards fertilization, due to the total harvest of the plant, which does not leave straw residue and thus extracts large quantities of nutrients from the soil. This can lead to decrease in the productivity and the quality of the silage. In order to maintain the desired characteristics of good silage, it is necessary to efficiently replace (through chemical fertilization: green/organic) the nutrients absorbed by the culture and exported in the harvest (França and Coelho, 2001).

The effect of organic matter on productivity can be direct, by means of nutrient supply or by bettering the physical properties of the soil, which improves the environment and stimulates plant development. Poultry litter, in addition to being rich in nutrients, improves crop productivity at a reduced cost. However, it should be emphasized that the use of organic fertilizers promotes the slow and gradual release of nutrients with the advantage of increasing the soil organic matter (SOM) content. The SOM content is considered one of the main indicators of sustainability and environmental quality in agroecosystems (Sá et al., 2001).

Alterations in the soil environment due to the addition of organic waste can affect soil microorganisms that are considered indicators of sustainability and environmental quality in agrosystems. Soils that have high microbial biomass (SMB) content are capable of not only storing, but also cycling more nutrients in the system (Berthrong et al., 2013). Soil respiration is defined as the biological oxidation of organic matter to CO_2 through the metabolism of aerobic microorganisms and occupies a key role in the carbon cycle of terrestrial ecosystems.

The evaluation of soil respiration is the most frequent technique to quantify microbial activity. It is positively related to organic matter content and microbial biomass (Alef and Nannipieri, 1995). The relationship between SMB and total organic carbon, called the microbial quotient (*q*MIC), is used as an indicator that reflects the efficiency of the transformation and conversion of organic matter C into microbial C (Baretta et al., 2005).

There is a verifiable necessity for wider studies related to the use of poultry litter as organic fertilizer in the productivity of cultures, as well as its effect on soil microorganisms. This study evaluated the productivity of corn for silage and the behavior of microbiological attributes of the soil with the use of poultry litter in the fertilization.

MATERIALS AND METHODS

The study was developed on the experimental farm of the Universidade Estadual do Norte do Paraná – *Campus* Luiz Meneghel (UENP/CLM), in Bandeirantes city (state of Paraná) (23°06'36"S; 50°27'28"W) (mean altitude of 420 m in typical eutrophic RED LATOSOL (LVef3) with no-tillage corn over black oats. The chemical characteristics are described in Table 1.

Random block design was considered, with subdivided plots. The blocks had four rows, the main plot nine treatments. The plots consisted of a control treatment with mineral fertilization (MF) (33 Kg N, 80 Kg P_2O_5 and 80 Kg K_2O per hectare). The treatments with poultry litter received, at sowing, 1/3 of the mineral fertilization (initial dose of the plant), while the plots of the MF treatment received the rest in the sowing furrows (Table 2).

A hybrid cultivar of corn (*Zea mays* L.) 2b810PW, of medium to high productivity, with a density of 55,000 plants ha^{-1} and spacing between rows of 0.90 m, was used for the test. Each experimental plot was 6.3 m long and 5.0 m wide, with a total area of 31.5 m^2. The cover fertilization was carried out when the plants presented 5 to 6 totally unrolled leaves in the vegetative stages V5 and V6 (Magalhães and Durães, 2008) and received 200 kg ha^{-1} of urea (Raij et al., 1996).

The litter was collected from poultry that had the same producer (2nd flock of broilers). The chemical characteristics of the litters are found in Table 3. The nutrient levels of the poultry litter are found in Table 4.

A collection of soil for chemical analysis was carried out at the beginning of the experiment and used to determine the need for lime. A dose of 1.2 Mg ha^{-1} was distributed in the total area of the experiment (Caires et al., 2006).

The soil collections for the microbiological analyses were carried

Table 1. Chemical properties of the soil at 0 to 20 cm deep.

Organic Mat. ($g.Kg^{-1}$)	pH ($CaCl_2$)	P ($mg.dm^{-3}$)	K ($cmol_c.dm^{-3}$)	Ca ($cmol_c.dm^{-3}$)	Mg ($cmol_c.dm^{-3}$)	Al ($cmol_c.dm^{-3}$)	CEC
22.77	4.44	5.19	0.16	5.89	1.93	0.35	12.91

P = Phosphorus; K = Potassium; Ca = Calcium; Mg = Magnesium; Al = Aluminum; CEC = Cation Exchange Capacity.

Table 2. Description of the treatments, formed by mineral fertilization (MF), rice straw (RS) and wood shavings (WSH).

Treatment	Description
MF	Mineral Fertilization – MF
2.5 RS	1/3 MF + 2.5 Mg ha^{-1} of Rice Straw (RS)
5.0 RS	1/3 MF + 5.0 Mg ha^{-1} of Rice Straw (RS)
7.5 RS	1/3 MF + 7.5 Mg ha^{-1} of Rice Straw (RS)
10.0 RS	1/3 MF + 10.0 Mg ha^{-1} of Rice Straw (RS)
2.5 WSH	1/3 MF + 2.5 Mg ha^{-1} of Wood Shavings (WSH)
5.0 WSH	1/3 MF + 5.0 Mg ha^{-1} of Wood Shavings (WSH)
7.5 WSH	1/3 MF + 7.5 Mg ha^{-1} of Wood Shavings (WSH)
10 WSH	1/3 MF + 10.0 Mg ha^{-1} of Wood Shavings (WSH)

Table 3. Chemical analysis of the poultry litter (wood shavings [WSH] and rice straw [RS]).

Poultry litter	P	K	Ca	Mg	S	C	N	C/N	B	Cu	Fe	Mg	Zn
	g kg^{-1}					%			mg kg^{-1}				
WSH	6.2	17.8	16.4	5.5	3.1	30.6	1.5	19.3	37.2	243.8	2114.8	348.3	203
RS	3.9	13.7	11.2	4.0	2.9	28.7	1.2	23.3	28.4	159.8	4853.4	444.3	130.5

P = Phosphorus; K = Potassium; Ca = Calcium; Mg = Magnesium; S = Sulfur; C = Carbon; N = Nitrogen; C/N = Carbon/Nitrogen ratio; B = Boron; Cu = Copper; Fe = Iron; Mn = Manganese; Zn = Zinc; WSH = wood shavings and RS = rice straw.

Table 4. Nutrient levels of the poultry litter in each experimental plot.

Trat.	Parameter [1]										
	N	K	Ca	Mg	S	P	B	Cu	Fe	Mg	Zn
	kg ha^{-1}						g ha^{-1}				
2.5 RS	30.8	34.3	28.1	10.2	7.2	9.9	71.2	399.6	12133.6	1110.8	326.2
5.0 RS	61.6	68.6	56.2	20.4	14.4	19.8	142.4	799.2	24267.2	2221.6	652.4
7.5 RS	92.4	102.9	84.3	30.6	21.6	29.7	213.6	1198.8	36400.8	3332.4	978.6
10 RS	123.2	137.2	112.4	40.8	28.8	39.6	284.8	1598.4	48534.4	4443.2	1304.8
2.5 WSH	39.6	44.6	41.2	13.8	7.7	15.6	93.0	609.6	5286.9	870.9	509.1
5.0 WSH	79.2	89.2	82.4	27.6	15.4	31.2	186.0	1219.2	10573.8	1741.8	1018.2
7.5 WSH	118.8	133.8	123.6	41.4	23.1	46.8	279.0	1828.8	15860.7	2612.7	1527.3
10 WSH	158.4	178.4	164.8	55.2	30.8	62.4	372.0	2438.4	21147.6	3483.6	2036.4

[1] P = Phosphorus; K = Potassium; Ca = Calcium; Mg = Magnesium; S = Sulfur; C = Carbon; N = Nitrogen; C/N = Carbon/Nitrogen ratio; B = Boron; Cu = Copper; Fe = Iron; Mn = Manganese; Zn = Zinc; WSH = wood shavings and RS = rice straw.

out at 0 to 10 cm deep in the inter-row of the culture at two different times: post-poultry litter (A) and post-herbicide application (B). Each sample was composed of 7 simple subsamples, homogenized and sieved in a 2 mm mesh at a humidity adjusted to 60% of field capacity. Microbial biomass carbon (MBC) was determined by the fumigation-extraction method (Vance et al., 1987). Walkley and

Black (1934) determined the method used to analyze total organic carbon (TOC). The MBC/TOC ratio was calculated from the MBC values and the TOC contents (Sparling, 1992). Respiratory activity was determined by the quantification of C-CO_2, according to Silva et al. (2007) and the metabolic quotient (qCO_2) is obtained by the ratio between respiration and MBC.

In order to determine the mean productivity of dry mass per plant and per hectare, plants were collected from plots composed of three rows, two linear meters long (6 plants/row, totaling 18 plants per plot. All of the plants were then weighed and shredded into particles with a mean size of two centimeters using a forage harvester (JF92-Z10 series 2). Duplicate samples were removed from each plot. The samples were weighed and placed in a laboratory oven at 65°C with artificial ventilation for 72 h to determine the percentage of dry matter. After the determination of the dry matter (DM), the levels of mineral matter (MM), ether extract (EE) and crude protein (CP) were determined (Detmann et al., 2012).

The results were submitted to analysis of variance (ANOVA), followed by the Tukey test, considering the level of 5% probability and using the program R (R Development Core Team, 2011).

RESULTS

Microbiological parameters of the soil

The use and management of the soil promoted significant alterations in its microbiological parameters. These parameters were mainly influenced by the addition of poultry litter after mineral fertilization. The MBC values were similar between the MF treatment and the treatments that received wood shavings at every dose and at 5.0 and 7.5 Mg ha^{-1} RS in collection A. In collection B, the treatment that did not receive any type of organic fertilizer presented the lowest value for this parameter. In addition, in every treatment in collection B, there was a significant decrease in MBC in comparison to collection A. As regards the variable total organic carbon (TOC), the lowest values and consequently the lowest reduction were found when analyzed between the collections (about 8 to 10%) in most doses of organic fertilizer and in the MF treatment. Comparison of the times of collections A and B in the microbial quotient (*q*MIC) analysis shows that these values increased in the treatments that received rice straw. The opposite occurred with the treatments that only received mineral fertilization and treatment with wood shavings. Analyzing soil basal respiration (SBR) in collection A, lower values for the MF, 2.5 RS and 2.5 WSH treatments are observed. This repeats in collection B, but only for the treatments with organic fertilization at low doses. In the MF treatment, there is a significant increase. This was reflected in the metabolic quotient (qCO_2), with the highest value in this treatment (Table 5).

The increase in MBC may be related to the larger quantity of organic waste, and can be attributed to the increase in the organic matter content and soil nutrients, which favor microbial growth (Lopes, 2001). Under natural conditions, microorganisms are found in equilibrium, where they depend on natural soil conditions. This equilibrium is frequently disturbed in cultivated areas (Silva et al., 2013).

The fall in MBC at the time of collection B may be related to the application of herbicide in the MF treatment. The application of herbicide promotes reduction in the quantity and even alters the composition of the SMB (Venzke Filho et al., 2008). Kaschuk et al. (2010) also reported that the application of herbicides in repeated harvests compromised the survival and the development of the microbial biomass and, in most cases, there is a decrease in the efficiency of the use of soil carbon resources; however, these agrochemical effects may be transitory (Silva et al., 2010). This is related to what has been observed by Ferreira et al. (2007), who demonstrated that a summer culture, when fully established, can stimulate the soil microbial community by means of effects on the rhizosphere.

Based on the results, there was direct influence of the SMB on the qCO_2 variations; however, there was an expressive increase in the metabolic activity of the microorganisms after application of herbicide (B), with the occurrence of greater stress in the treatments with mineral fertilization compared to the treatments with poultry litter. This may be related to cultural waste and/or recently-added material to the soil that acts in the aggregation of the OM to the soil particles, becoming a physical barrier protecting the SMB (Six et al., 2006).

Impact produced by soil management promotes deviation of energy from growth and reproduction to cellular maintenance, elevating the qCO_2 values. During stress in the SMB, energy routing occurs for cellular maintenance in the place of growth, so that a proportion of biomass carbon is lost in the form of CO_2 (Araújo and Monteiro, 2007). The results demonstrate that the treatments with poultry litter had a lower adverse effect on the microbial community than those that did not receive it, maintaining greater efficiency in the cycling of the nutrients present in the organic fraction of these materials. With low values of qCO_2, there are lower values of lost carbon.

High values of qCO_2 are indications of greater energy requirement by the SMB and consequent acceleration of the decomposition of the SOM. This could be reflected in a decrease in the stock and the quality of the organic matter (Baretta et al., 2005).

A tendency in the efficient use of total organic carbon was verified in this study. A higher rate of decomposition was observed in the treatments with rice straw in relation to wood shavings, because rice straw has a less lignified composition compared to wood shavings.

The microbial quotient (*q*MIC) has been used as an indicator of the quality of the organic matter present in the soil. This value expresses the efficiency of microbial biomass in the use of C (Baretta et al., 2005). Higher and lower values express accumulation or loss of C, respectively. The authors consider the value of 2.2% to be the level at which the soil presents equilibrium and is

Table 5. Mean of the values composed of four replications at two collection times, demonstrating the behavior of the microbiological parameters of the soil due to the doses of poultry litter used in the treatments.

Treatment	MBC[1]		TOC[2]		*q*MIC[3]		SBR[4]		*q*CO_2[5]	
	Collection		Collection		Collection		Collection		Collection	
	A*	B**	A	B	A	B	A	B	A	B
MIN	175.503^{aA}	63.809^{dB}	16.359^{bA}	14.995^{aB}	1.072^{aA}	0.431^{cB}	0.457^{cA}	0.719^{aB}	2.611^{eA}	11.356^{aB}
2.5 RS	130.249^{cA}	119.280^{bcA}	18.306^{abA}	14.022^{aB}	0.712^{cA}	0.850^{bB}	0.471^{bcA}	0.221^{cB}	3.613^{cdeA}	1.863^{dB}
5.0 RS	166.684^{abA}	166.184^{aA}	17.722^{abA}	14.411^{aB}	0.943^{abA}	1.157^{aB}	0.653^{abA}	0.366^{cB}	3.903^{bcA}	2.216^{dB}
7.5 RS	159.819^{abA}	139.205^{abB}	18.306^{abA}	14.801^{aB}	0.879^{abcA}	0.947^{bA}	0.606^{bcA}	0.573^{abA}	3.800^{cdA}	4.136^{bcA}
10 RS	143.189^{bcA}	133.714^{bcA}	16.943^{abA}	15.385^{aB}	0.849^{abcA}	0.868^{bA}	0.528^{bcA}	0.540^{bA}	3.696^{cdA}	4.053^{bcA}
2.5 WSH	169.350^{abA}	119.887^{bcB}	17.332^{abA}	14.216^{aB}	0.979^{abA}	0.809^{bB}	0.466^{bcA}	0.347^{cB}	2.759^{deA}	3.024^{cdA}
5.0 WSH	158.039^{abA}	109.552^{cB}	19.280^{aA}	14.411^{aB}	0.823^{bcA}	0.760^{bA}	0.665^{abA}	0.545^{bA}	4.207^{abcA}	4.251^{bcA}
7.5 WSH	171.352^{aA}	120.853^{bcB}	18.306^{abA}	14.995^{aB}	0.936^{abcA}	0.805^{bB}	0.834^{aA}	0.646^{abB}	4.869^{abA}	5.370^{bA}
10 WSH	169.910^{abA}	123.209^{bcB}	16.748^{bA}	14.995^{aB}	1.021^{abA}	0.823^{bA}	0.851^{aA}	0.573^{abB}	5.004^{aA}	4.683^{bcA}

Means followed by the same lower case letter in the columns and means followed by the same upper case letter in the rows do not differ according to the Tukey test ($P<0.05$). *collection A - Post-poultry litter; **collection B – Mineral fertilizer; [1]microbial biomass carbon of the soil; [2]total organic carbon; [3]microbial quotient; [4]soil basal respiration; [5]metabolic quotient.

better observed in soils with native forest (Wardle and Hungria, 1994; Baretta et al., 2005).

The elevation of this index is a favorable condition that produces an optimized environment for the microbiota of the soil. This may be related to the high continuous and varied input of substrates that influence the rate of decomposition of this material (Cardoso et al., 2009; Silva et al., 2010).

Fluctuations in the *q*MIC values reflect the entry of organic matter in the soil, efficiency of MBC conversion, carbon losses and the stabilization of organic carbon by the mineral fraction of the soil. This relationship indicates if the C is in equilibrium. This carbon is present in the labile part or in the recalcitrant part of the soil. The labile part acts directly in the C cycling and can respond more rapidly to change in the levels of entry and decomposition of organic matter (Balota et al., 1998). According to Silva et al. (2010), low relationships in the *q*MIC present a condition of stress, and under these conditions the rate of C use by the SMB is lower.

Productivity of the silage

The results as regards the productivity parameters of corn for silage high content of CP and EE was presented by the treatment with mineral fertilization with 15.36 g and 6.64 g DM^{-1} (per plant), respectively. However, the treatment with rice straw presented, in the ether extract, a value equal to the MF and WSH treatments. There was no significant difference between the treatments in the other attributes (Table 6).

The calculation of the diet of the animals is based on the percentage of DM present in the silage. Thus, the values of this attribute were among the most indicated for the conservation and production of the corn (28 to 35% of DM) (Cruz and Pereira Filho, 2001).

The higher production with mineral fertilizer compared to poultry litter is connected to the greater solubility of nitrogen (N) and phosphorus (P) in the chemical fertilizers, which results in the their greater initial availability to the plant (Lourenço et al., 2013). In the poultry litter, the water soluble fraction of these elements represents less than 0.25% of their total and the rest is in organic forms that need mineralization so that these nutrients are released and then absorbed by the plants (CQFSRS/SC, 2004).

Going against the literature, the test in this study presented the same percentages of dry matter between the treatments. Hirzel and Walter (2008), working with three treatments (control without any fertilization, treatment with only mineral fertilization and organic fertilization with poultry litter), and using 20 Mg ha^{-1} for three harvests,

Table 6. Mean values of the productivity of dry matter and the corn silage components in the fertilized dry mass with different types of fertilizer.

Type of fertilizer	%DM(%)[2]	DM(Mg ha^{-1})[3]	EE(g)[4]	CP(g)[5]	OM(g)[6]	MM(g)[7]
Mineral	28.23^{a}	13.22^{a}	6.64^{a}	15.36^{a}	230.46^{a}	9.88^{b}
Rice Straw	29.00^{a}	12.60^{a}	6.27^{ab}	14.06^{b}	221.12^{a}	10.89^{a}
Wood Shavings	28.92^{a}	13.88^{a}	5.72^{b}	14.07^{b}	227.06^{a}	10.49^{ab}
cv (%)[1]	7.40	7.40	11.81	8.26	7.59	1022

Means followed by the same letter in the columns do not differ according to the Tukey test ($P<0.05$). [1]coefficient of variation; [2]percentage of dry mass; [3]produtivity of silage in the dry mass; [4]ether extract; [5]crude protein; [6] organic matter; [7]mineral matter.

verified that there was no difference in the productivity of DM in any of the harvests, demonstrating that organic fertilization made nutrients available to plants effectively. In addition, the response is due to the larger quantity of nutrients available in the treatments with poultry litter (Cesarino, 2006; Graciano et al., 2006).

The following are advantages of the use of wastes of animal origin: improvement in the physical and chemical properties of the soil and in the supply of nutrients; increase in organic matter content, thus improving the infiltration of water and increasing the cation exchange capacity. Fertilization with poultry litter was shown to be an important alternative to the producer in unfavorable climatic situations in the production of silage, considering the benefits that organic fertilization brings to the soil (Hoffman et al., 2001).

The decomposition velocity of wastes is influenced by their chemical characteristics and the environment where they are found. This difference in the decomposition time of manure in relation to cellulosic materials assures a continuous flow of nutrients in the soil and determines a slow and prolonged rate of release of the nutrients that are made available to the plants (Costa et al., 2009). As regards the OM component, the type of fertilizer did not influence the response, because all of the treatments were similar. As for mineral matter, the values were also similar, with higher values in the treatments with organic fertilization. This was also reported by Cesarino (2006), who observed high values of ashes for the treatments with organic wastes. They are more diluted in the plants probably due to these wastes.

The effects on the productivity of the silage, taking into consideration the sources and the doses of fertilization, are described in Table 5. There were no differences in the productivity results in percentage and per area of DM.

The different treatments did not influence the ether extract values of the plant. All of them were similar to the treatments that received only mineral fertilization; whereas, for the fertilization with wood shavings, the 10 WSH treatment had the highest content of this element (7.25 g DM^{-1}). On the other hand, the 2.5 WSH treatment presented the lowest content (4.35 g DM^{-1}). The ether extract value for rice straw in the 7.5 RS treatment was 7.21 g DM^{-1}. The highest content in grams of protein in the plant was observed in the 7.5 RS treatment (15.58 g DM^{-1}) and the lowest was found in the 5.0 RS treatment (12.27 g DM^{-1}). The other treatments did not present differences between the treatments (Table 7).

In the several studies carried out using mineral and organic fertilization, all obtained the same results. Gomes et al. (2005) and Konzen and Alvarenga (2003) did not observe differences in the yield of the corn culture with the chemical fertilizer and organic compound association at different doses, demonstrating that the nutrients, mainly the nitrogen that is found protected in the organic fertilizers (thus avoiding losses by volatilization), are effective in the fertilization of large cultures. Results were obtained in the study of productivity of diverse foragers like Marandú, Tanzania and Tifton-85 (Menezes et al., 2009).

Graciano et al. (2006), working with the production and analyses of components of arracacha (Peruvian carrot) in dystrophic RED LATOSOL, observed high contents of proteins, lipids, fibers and proteins of plants cultivated in soil with poultry litter fertilization (superior to mineral fertilization). The high yield in the production of corn by organic fertilization may be related to elevation of the dose of manure (animal excrement) (Silva et al., 2004; Cesarino, 2006). In the present study, the same result was observed in the treatment with fertilization with wood shavings, however, in 10.0 Mg ha^{-1} of this compound, the same yield was not observed.

The crude protein content in the foliar tissue is directly related to the nitrogen content, which is, on average, 16% of the nitrogen in the crude protein. Thus, its value depends on the extraction of nitrogen by the plant. Grasses generally extract elevated quantities of nitrogen and their response varies depending on the time of year, species, nutrient source, soil fertility and development stage of the plant (Vielmo, 2008).

According to the results obtained by Colussi (2013), who researched the development of the grass Tifton 85 using poultry litter as a source of fertilization in a series of four cuts, observed that the protein was superior in the third and fourth cuts, demonstrating the slower cycling of the element. In contrast, it was shown to be effective in the exchange of mineral fertilization for organic.

Organic matter and mineral matter did not differ

Table 7. Mean values of the dry mass productivity and the fertilized corn silage components with different sources and doses of poultry litter.

Treatment	%DM(%)[2]	DM(Mg ha^{-1})[3]	PLANT DM(g)[4]	EE(g)[5]	CP(g)[6]	OM(g)[7]	MM(g)[8]
MF [9]	28.23[a]	16.15[a]	240.35[a]	6.65[a]	15.36[ab]	230.47[a]	9.88[a]
2.5 RS	28.91[a]	14.94[a]	221.78[a]	5.96[ab]	13.59[ab]	210.86[a]	10.92[a]
5.0 RS	28.31[a]	14.63[a]	219.25[a]	5.92[ab]	12.27[b]	209.10[a]	10.15[a]
7.5 RS	30.28[a]	16.25[a]	249.66[a]	7.21[a]	15.58[a]	239.13[a]	10.53[a]
10 RS	28.51[a]	16.01[a]	241.49[a]	6.02[ab]	14.83[ab]	229.50[a]	11.98[a]
2.5 WSH	28.38[a]	15.56[a]	224.93[a]	4.35[b]	12.74[ab]	215.13[a]	9.80[a]
5.0 WSH	28.61[a]	15.67[a]	231.70[a]	5.36[ab]	13.94[ab]	221.64[a]	10.06[a]
7.5 WSH	29.01[a]	15.75[a]	241.52[a]	5.94[ab]	14.96[ab]	230.61[a]	10.91[a]
10 WSH	29.69[a]	17.37[a]	252.08[a]	7.25[a]	14.68[ab]	240.90[a]	11.19[a]
cv (%)[1]	8.22	11.97	10.17	13.59	9.27	8.46	9.40

Means followed by the same letter in the columns do not differ according to the Tukey test (P<0.05). [1]coefficient of variation; [2]percentage of dry matter; [3]dry matter; [4]dry mass of each plant; [5]ether extract; [6]crude protein; [7]organic matter; [8]mineral matter, [9]mineral fertilization.

between the treatments tested. According to Sbardelotto and Cassol (2009), the absence of significant response in the treatments is due to the soil presenting high initial fertility.

Conclusions

Fertilization with poultry litter stimulated microbial activity in the soil, promoting greater mineralization and solubilization of organic matter nutrients, inducing better use of soil C. This was reflected in the production of corn silage. A 2/3 reduction of the mineral fertilization in the use of organic fertilization can be proposed, without loss in plant quality or production.

Conflict of Interests

The authors have not declared any conflict of interests.

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