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RESEARCH ARTICLE

AGRONOMIC PERFORMANCE AND PHYSICAL CHARACTERISTICS OF LETTUCE UNDER DIFFERENT FERTILIZER SOURCES

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ABSTRACT

In order to promote increased efficiency of cultivation techniques for higher yield of culture in a sustainable manner, the objective of this study was to evaluate alternative sources of lettuce fertilization in the north of Mato Grosso. The cultivar Marisa was used to obtain answers regarding the agronomic performance and physical characteristics. The experimental design was a complete randomized block design with four replications. The treatments were: T1 - control (without fertilizer); T2 - chemical fertilizer (NPK); T3 - chicken manure; T4 - Sheep manure and T5 - Cotton waste (by-products of cotton trees). These were evaluated: shoot diameter, fresh matter (without root), dry matter, leaf length, number of leaves, daily increment and commercial productivity. The fertilization with animal manure and vegetable waste presented better results in relation to chemical fertilizer (NPK). The incorporation of sheep manure provides greater shoot diameter, fresh matter, dry matter, leaf length, daily increment and commercial productivity.

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INTRODUCTION

Lettuce (*Lactuca sativa* L.) is grown in all regions of Brazil, standing out as the main vegetable consumed by the population because of its taste, nutritional quality and low cost to the consumer (Teodoro *et al*., 2016). Is important in the diet, due to its high content of vitamin A, vitamins B1 and B2, vitamin C, calcium and iron (Fernandes *et al*., 2002). On the other hand, it has a low calorie content (Oliveira *et al*., 2004) and consumption occurs *in natura* and in all kinds of salads (Zuffo *et al*., 2016). Among the lettuce cultivars on the market, the crispy type is best suited for summer cultivation. For Rodrigues *et al*. (2007), this type of lettuce stands out for disease resistance, bolting, and present good leaf disposal, transportation resistance, longer post-harvest period and better taste. The ideal soil for the cultivation of this vegetable is of medium texture, rich in organic matter and with good availability of nutrients. The higher yields can be obtained with improved chemical and physico-chemical soil, for example, the use of organic compounds (Souza *et al*., 2005). The vegetables differ in the macronutrient requirements and absorption pattern during growth. To Gomes (2001), in general, in lettuce crop, the absorption of N, P and K follow the same trend as the rate of biomass accumulation of the culture. In order to reduce expenses and inorganic fertilizers for a more sustainable production, research work has studied alternative ways of fertilizing with organic fertilizers, because one of the barriers to production is increasing and maintaining soil fertility (Khatounian, 2001). According to Espíndola *et al*. (2006), the organic fertilizer, in principle, establishes production systems based on technologies and processes, ie, a set of procedures involving the plant, soil and climatic conditions, producing quality food, with characteristics and unique flavors, that meets consumer expectations. Lettuce is generally responsive to organic fertilization; however, there are variations in the organic source used (Teodoro *et al*., 2016). According to Oliveira *et al*. (2010) the leafy vegetables

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respond well to organic fertilizers. These have variable composition depending on their origin, moisture content and processing before its application. Soil mineralization of nutrients like nitrogen and phosphorus depends mainly on the carbon/nitrogen (C/N) ratio of the organic material. According to Trani *et al*. (2013), animal products suffer a faster mineralization process than plant products when subjected to the same ambient temperature and humidity conditions in the soil. The ease of decomposition depends on the C/N ratio, which is the proportion of carbon compared to nitrogen contained in the material. The considered ideal C/N ratio is that with 30/1. When the ratio is higher than the ideal, the microorganism growth is delayed by the lack of nitrogen and thus the degradation of the compounds becomes slow; however, if the ratio is too low, the excess of nitrogen accelerates the decomposition process, and causes the oxygen to be spent quickly, which can lead to the creation of anaerobic zones in the system (EMBRAPA, 2006). Given the above, in order to promote increased efficiency of cultivation techniques for higher yield of culture in a sustainable manner, the objective of this study was to evaluate different sources of fertilizer on the agronomic performance and physical characteristics of lettuce cv. Marisa.

MATERIAL AND METHODS

The experiment was conducted under field conditions in the experimental area of the Federal University of Mato Grosso, campus of Sinop, with geographic coordinates 11º50' S latitude and 55º38' W longitude and altitude of 340 m. According to Köppen classification, the climate is Aw, with an annual average temperature of 24ºC. Daily weather data (Figure 1) were made available by the National Institute of Meteorology - INMET.

The soil is classified as Red-Yellow Latosol (RYL) with clayey texture (Santos *et al*., 2006), with the following characteristics before the implementation of the experiment in the layer 0-20 cm: pH in $CaCl_2$ = 5.2; OM = 21.3 g dm^{-3}; P = 2.9 mg dm^{-3}; K = 37 mg dm^{-3}; Ca = 1.8 mmol dm^{-3}; Mg = 0.9 mmol dm^{-3}; H + Al = 3.5 mmol dm^{-3}; SB = 2.4 mmol dm^{-3}; V% = 50.6. After analyzing the soil, soil correction was performed with dolomitic limestone incorporated into the soil 45 days before the transplanting, aiming to raise the base saturation to 80%. The experimental design was a complete randomized block design with four replications and five treatments. The treatments were: T1 - control (without fertilizer); T2 - chemical fertilizer (NPK); T3 - chicken manure; T4 - Sheep manure and T5 - Cotton waste (by-products of cotton trees). Animal manures and plant waste were obtained in agribusiness and rural properties in the city. The chemical characteristics were observed through analyzes (Table 1). The cultivar Marisa of the crispy group was used; it presents high heat resistance and bolting, and tolerance to Fusarium wilt. The implementation of the culture was held in March 2011 by seedlings produced in a protected environment. The seeds were sown in commercial substrate PLANTMAX® contained in polystyrene trays with 128 cells.

The seedbeds were fertilized and incorporated 15 days before transplanting the seedlings, according to established treatments. Chemical fertilization consisted of 277 kg ha^{-1} of formulated N-P_2O_5-K_2O (04-14-08). Fertilization with cotton waste, sheep manure and chicken manure were composed of 15 ton ha^{-1} of each component. In the control, there was just liming. The transplanting was done when the seedlings had three open leaves. Each plot was conducted with 4.0 m long and 1.20 m wide, with 0.25 x 0.25 cm spacing between plants, totaling 56 plants. As cultural practices, irrigation by sprinkler was held daily, when necessary, in order to maintain the moisture content in the soil at field capacity.

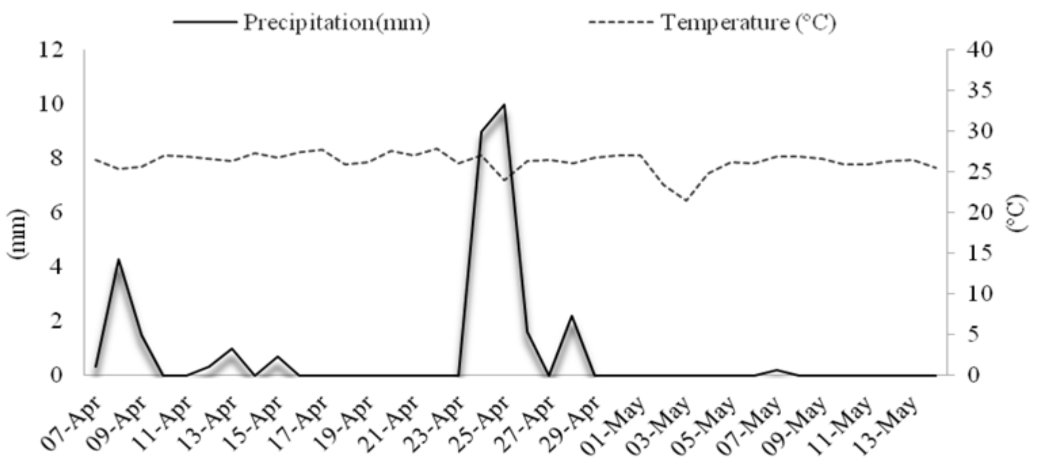

Figure 1. Daily averages of rainfall and air temperature occurred in Sinop, Mato Grosso, in March and April 2011, during the experiment. Source: National Institute of Meteorology (INMET)

Table 1. Chemical characterization of chicken manure (CM), sheep manure (SM) and cotton waste (CW) obtained in agribusiness and rural properties for the experiment. Sinop – MT, 2011

Organic Material	C/N	C	N	P	K	Ca	Mg	S	Zn	Cu	OM
		- - - - - - - - - - - - - (g/Kg) - - - - - - - - - - - - -							- (mg/Kg) -		(dag kg^{-1})
CM	10/1	140.0	14.0	8.0	7.0	23.0	5.0	2	138	14	24.4
SM	32/1	406.4	12.7	7.1	14.5	12.0	4	17	117	12	18.0
CW	11/1	243.1	22.1	6.3	2.1	12.8	3.6	0.3	41.3	18.3	9.2

Manual weed control was also performed. No insecticide and fungicide applications were needed during the experiment. The harvest was held 38 days after transplanting the seedlings. For the evaluations, the two lines outside the plot were disregarded, as well as one meter at the ends of the central lines, being considered as useful plot the 14 central plants of the seedbed. We evaluated the shoot diameter - with the aid of a fabric tape measure, in ten plants per plot, measuring the transverse diameter of shoot (cm); fresh matter (without root) - with the aid of a precision scale model UD 1500 ($g.plant^{-1}$); dry matter - the shoot of the plant was subjected to pre-drying and subsequently taken to an oven with air circulation at a temperature of 65ºC and then weighed with a precision scale model UD 1500 ($g.plant^{-1}$); leaf length - with the aid of a millimeter ruler on ten plants per plot (cm); number of leaves - manual count conducted in 10 plants per plot; daily increment - ratio between fresh matter (without root) and cycle, including the period from the transplanting to harvest and commercial productivity - to estimate the total productivity, considering 116,666 plants per hectare. For the total weight of the commercial head, the plants were defoliated up to the ideal marketing point. For the estimation of commercial production, the lettuce plants were weighed and the values were converted to kg ha^{-1}. The data were submitted to analysis of variance by F test and the means were compared by the Scott-Knott test (1974), with the help of the statistical package SISVAR® (Ferreira, 2011). The precision was evaluated by assessing the selective accuracy (Resende; Duarte, 2007), using the estimator:

$$r = \sqrt{1 \quad \frac{1}{F_c}}\ x\ 100$$

where: *r* is the accuracy expressed as a percentage; F_c is the value of F calculated for the source of variation fertilizing in analysis of variance.

RESULTS AND DISCUSSION

The accuracy estimates reflect the precision of the experiments conducted. According to Resende; Duarte (2007), accuracy estimates above 0.70 are considered of great magnitude, which was observed for all characteristics, proving the high experimental precision. The fertilizer sources differed ($p \leq 0.01$) for all characteristics (Table 2). In general, the fertilizer sources with animal manure and plant waste showed better results for most characters, except for the number of leaves that showed similar results when using chemical fertilizer.

Similar results were observed by Abreu *et al.* (2010) and Peixoto Filho *et al.* (2013) evaluating the performance of lettuce crop under chemical and organic fertilizer. It was observed that the addition of organic fertilizer to the soil provided improvements in physical and chemical conditions, increasing the macro and micronutrients, providing conditions for greater agronomic performance. The commercial quality of lettuce is assessed by some essential characteristics to meet the consumer market (Doriguetto, 2014). Accordingly, the evaluation of the shoot diameter is one of the most important characteristics. Note that the shoot diameter, when sheep manure is used as fertilizer source, was higher than 14, 27, 38 and 57% respectively, when compared to fertilization with chicken manure, cotton waste, chemical fertilizers and control (Table 2). Similar results were described by Oliveira *et al.* (2010), in which the best results were observed for organic fertilizer. However, Moreira *et al*. (2014) found better results for organic fertilization with organic compost, bovine manure and castor bean cake. For the analysis of fresh matter, the sheep manure was higher than all treatments, with 34, 59, 73 and 95% respectively, when compared to chicken manure, cotton waste, chemical fertilizers and control (Table 2). The dry matter also showed the same response as for the source of fertilizer used, showing superiority of 3.5, 4.9, 6.0 and 7.8 grams compared to fertilization with chicken manure, cotton waste, chemical fertilizer and control. For leaf length, the sheep manure was also more efficient, presenting leaves with an average of 16.72 cm, followed by chicken manure with 14.88 cm. For the number of leaves per plant, the fertilizer sources did not influence its development, ranging from 16 to 18 leaves per plant. As for the control, the number of leaves was lower, with an average of 11 leaves per plant, although no statistical difference was found in the number of leaves among the types of fertilizer, except the witness. It is evidenced by the variables fresh matter and dry matter that the treatments made up of sheep manure provided higher leaf area. According to Zuffo *et al*. (2016) the plant dry matter is directly related to the binding capacity of atmospheric CO_2 by photosynthesis, and this is as higher as the greater the leaf area. In addition to the essential characteristics to meet the consumer market, it is of interest of producers to know alternatives that enable the maximization of yield and, therefore, profitability. In this sense, the daily increment of production in fresh matter is the gain of plant fresh matter per day. The fertilization with sheep manure provides best gain of daily increment with 4.84 g per day, as well as better commercial productivity with 18,453.0 kg ha^{-1}, exceeding other nutrient sources in at least 7837.8 kg.ha^{-1} (Table 2).

Table 2. Mean values of shoot diameter (SD - cm), fresh matter (FM - g), dry matter (DM - g), leaf length (LL - cm), number of leaves (NF), daily increment (DI - g.day) and commercial productivity (CP - kg.ha^{-1}), for the fertilizer sources, Sinop - MT, Brazil, in 2011

Fertilizer Sources	SD	FM	DM	LL	NF	DI	CP
Sheep manure	33.5 a	166.49 a	8.32 a	16.72 a	18.00 a	4.38 a	18453.0 a
Chicken manure	28.45 b	95.77 b	4.78 b	14.88 b	17.00 a	2.52 b	10615.2 b
Cotton residue	24.42 c	68.24 b	3.41 b	11.27 c	17.00 a	1.79 b	7563.2 b
Chemical (NPK)	20.83 d	44.65 c	2.23 c	10.71 c	16.00 a	1.17 c	4949.4 c
Control of the general average	14.44 e	9.3 c	0.46 c	7.78 d	11.00 b	0.25 c	1031.4 c
General mean	24.32	76.89	3.84	12.27	16.00	2.02	8522.5
p. value	**	**	**	**	**	**	**
Accuracy	0.99	0.97	0.98	0.99	0.97	0.98	0.98

** Significant at 1%. Means followed by the same letter in the column belong to the same group, by Scott Knott test at 5% probability.

In a study with application of some manures, Brito *et al*. (2005) concluded that the sheep manure was the residue that determined the major changes of soil chemical properties. The rate of decomposition and subsequent mineralization of organic residues directly affect the availability of nutrients for plants, particularly for those of short cycle, such as lettuce (Figueiredo *et al*. 2012).

According to Souza (2005), in conventional agriculture, the use of chemical fertilizers promotes, over time, a reduction in biological activity of the soil and can affect the productive performance of the crop. Penteado (2000) reports that lettuce plants have higher development using organic residue as it provides improvements in chemical, physical and biological conditions of the soil, promoting the growth of roots, soil aeration and water retention (Filgueira, 2000). In similar studies, Maia Neto (1988) evaluating the effect of organic fertilization on the behavior of lettuce cultivars in Mossoró-RN, found that the fertilization provided an increase in production and average mass of plants. When evaluating the influence of various kinds of soil organic fertilization on lettuce productivity, Andreani Junior; Galbiati Neto (2003) found that the coverage with sugarcane bagasse and rice straw provided greater weight gains when compared soil without cover system and chemical fertilization. Comparing the effect of different materials (rice straw, coffee husks, *Brachiaria brizantha*, sawdust, chemical fertilizer and control without fertilization) on lettuce yield, Carvalho *et al*. (2005) concluded that, regardless of the coverage used, the lettuce yield was always better in treatments that used organic fertilizer.

Thus, as seen in the results of this work and of several studies, the beneficial effect of organic fertilizer compared to chemical fertilizers or absence of fertilization is evident. The fertilization made from sheep manure has better results probably to its ideal C/N ratio (Table 1). However, chicken manure and cotton waste show C/N ratio of 10/1 and 11/1 respectively. It is evident that in these treatments, because of the high N content, the decomposition may have been accelerated, which is not beneficial for the culture. According to the chemical characterization of organic material, higher levels of potassium and sulfur in sheep manure was also found, improving lettuce development in this treatment (Table 1).

Conclusion

The fertilization with animal manure and vegetable waste presented better results in relation to chemical fertilizer (NPK). The incorporation of sheep manure provides greater shoot diameter, fresh matter, dry matter, leaf length, daily increase and commercial productivity.

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