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The Effects of Adding Agricultural Lime and Organic Matter in the Yield of Manioc Roots (*Manihot esculenta Crantz*)

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Abstract: The use of agricultural limestone and organic matter in the crops is given to increase the yield of the same, among these crops can be mentioned to the manioc, which needs to be paid to express all its potential in the field. A comparative experiment between different treatments is presented below. Four treatments were included, differentiated between control (without anything), combination of agricultural limestone and organic matter, agricultural limestone only and only organic matter, the analysis of variance (ANAVA) and the comparison of means were performed with the Duncan test at 5% error probability. The performance of manioc roots under each treatment was visualized. Result: The superior yield obtained by adding agricultural lime and organic matter, these additives incorporated into the soil have exceeded the average conditions of said soil for the growing of crops, such effect could be observed just by simply observing the vegetable ground covering of the soil caused by the crops and in the roots at the moment of the harvest. The application of agricultural lime and organic matter produced improvements in the yield of manioc roots and the increase in performance with the application of both additives was greater than 75%.

Key words: manioc, agricultural limestone, organic matter, roots and yield

1. Introduction

According to Boareto and Neptunia (1981) organic matter's tenor increases once animal manure is added to the soil.

Manioc tolerates the acidic levels of soil. At low pH levels, it presents a relatively superior production in comparison to other crops, such as soybeans and corn. The optimal interval of pH for its development is between 5.5 to 6.5. Acidic soil can become more productive by adding agricultural lime [1].

Few manioc producers exist in Paraguay, specifically those dedicated to family agriculture, who utilizes organic amendments or agricultural lime to improve the conditions of product in their crops. Surveys carried out within the framework of the Program to Support the Development of Small Cotton Farms show that 63% of producers in thirteen territorial intervention units are at a low technological level in relation to management and conservation of soils [2].

The objective of this research was to evaluate the effects of adding organic matter and agricultural lime in the yield of manioc roots.

2. Methodology

The research was accomplished in the company of *Arroyo Porã*, district of Escobar, department of Paraguarí, Paraguayan Republic. The premises are located 25.6° of latitude South and 57° of length to the East of Greenwich, with an altitude of 331 meters of sea level and with a regime of annual precipitation of 1,600 mm. Its soil belongs to the sub division Arenic Paleudalf, of the sand family with a landscape of hills,

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derived from sandstone, a flat relief, good drainage, free of stoniness and rockiness.

The treatments applied to the soil were as follows: (1) Without addition of organic matter or agricultural lime, (2) addition of one tonne per hectare of limestone, (3) addition of one tonne per hectare of limestone and 40 tons per hectare of bovine manure, (4) addition of 40 tons.

Treatments were made in four plots, 100 square meters each and statistical analysis was carried out as if it were a completely randomized experimental design, where the repetitions were given by the harvest of five plants within each plot. The analysis of variance (ANAVA) and the comparison of means were performed with the Duncan test at 5% error probability.

The variable measured was the yield of the roots in tons per hectare, planted at a density of 14,285 plants per hectare (1 m between lines and 0.70 m between plants). The variable was transformed using the square root, by the high value of the coefficient of variation. The growing period lasted from August 22, 2015 until April 23, 2016.

3. Results and Discussion

Table 1 shows the results of Variance Analysis of yield data obtained in the research.

It can be seen that there are statistical differences with a 12% probability of error, that is, there is 88% certainty that the analyzed treatments have statistical differences among themselves.

Table 2 shows the results of the comparison of mean by the Duncan method at 5% error probability.

Table 1 Results of the Variance Analysis of the performance data. Escobar 2015/2016.

Source of variation	Sum of Squares	Degrees of Freedom	Mean Squared	F-Score	Probability Value
Treatment	4.84	3	1.61	2.34	0.1122
Error	11.05	16	0.69		
Total	15.89	19			

Coefficient of Variation = 20.77%

Table 2 Mean results of the yield of manioc roots. Escobar. 2015/2016.

Yield of manioc roots (t ha^{-1})						
Treatments	Repetition					Mean
	1	2	3	4	5	
Without adding organic matter or agricultural lime	10,142	7,571	23,142	3,857	21,713	13,285A
Adding one tonne of agricultural lime per hectare	13,428	14,714	11,999	13,285	15,999	13 ,885 AB
Adding of one tonne of agricultural lime and 40 tons of bovine manure per hectare	36,141	15,428	23,285	20,285	21,428	23,313B
	21,999	21,285	8,714	10,571	15,714	15,656 AB

Mean that share the same letter are not statistically different, Duncan method at 5% error probability.

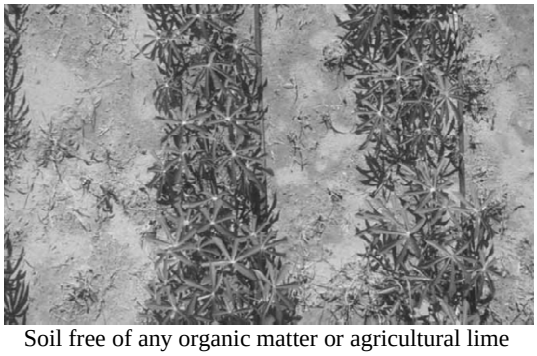
These results demonstrate the superior yield obtained by adding agricultural lime and bovine manure. These additives incorporated into the soil have surpassed the average conditions of said soil for the growing of crops, such effect could be noticed just by simply observing the vegetable ground covering of the soil caused by the crops and in the roots at the moment of the harvest, as seen in Fig. 1 and 2. The positive outcome in the improvement of the soil conditions matches the ones mentioned by Porta et al. (2003) [3], by attributing to organic matter and agricultural lime the betterment of physical, chemical and biological properties of the soil.

It can also be seen that there is a 75% increase in the yield of manioc roots when one ton of agricultural lime and 40 tons of bovine manure per hectare were added.

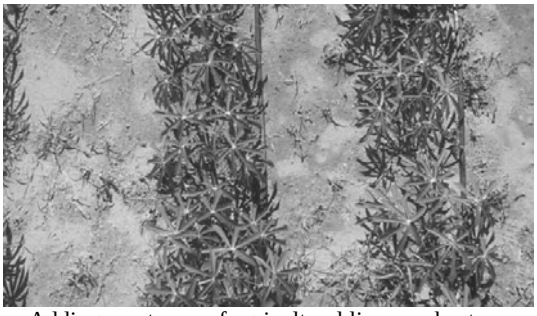
The addition of organic matter and agricultural lime have provided increases in yield of the crop, also improving the vegetative development of the plant and roots, as can be seen in Figs. 1 and 2. Similar results have been verified by Marcado et al. (1994) [4], with lime and Staut (2012) [5], with organic amendments.

Adding one tonne of lime and 40 tons of bovine manure per hectare

Adding 40 tons of bovine manure per hectare



Soil free of any organic matter or agricultural lime



Adding one tonne of agricultural lime per hectare

Fig. 1 Vegetable ground cover of the soil, 100 days after sowing manioc.

No adding of organic matter or agricultural lime

Adding one tone of lime per hectare

Adding one tone of lime and 40 tons of bovine manure per hectare

Adding 40 tons of bovine manure per hectare

Fig. 2 Manioc roots at the moment of harvest.

4. Conclusion

In the conditions of the present work it can be concluded that: (1) The application of agricultural lime and organic matter produced improvements in the yield of manioc roots (2) The increase in performance with the application of both additives was greater than 75%.

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