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RESEARCH ARTICLE **OPEN ACCESS**

APPLICATION OF ORGANOMINERAL AND MINERAL NITROGENATE FERTILIZER IN MAIZE CROP, IN COVERAGE, ON SOILS OF DIFFERENT TEXTURES

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ABSTRACT

The use of organomineral can improve the efficiency of nutrients mainly of nitrogen and, therefore, reduce the costs with fertilizer application. The application of organominerals in addition to providing nutrition improves soil quality. This study aimed to evaluate the effects of organomineral nitrogen fertilizer compared to mineral fertilizer on different soil textures in corn. Two trials were conducted in the city of Uberlândia-MG: one located near the BR 452 highway, km 141, at coordinate 18°55'28'' S 48°09'36'' W, clay soil. The other, at km 640 of BR 365, at coordinate 18°54'05'' S 48°25'20'' W, sandy soil. The design was in a 2 x 5 + 2 factorial scheme in randomized blocks with four replications, two application times, five doses of pelleted nitrogen organomineral fertilizer (40, 60, 80, 100 and 120% of the recommended nitrogen dose for the corn) and two additional ones with 100% of the mineral nitrogen recommendation. Regarding the application time, the application subdivision in V2 (50%) + V4 (50%) presented the best increments for column and stalk diameter, stalk length and number of grains per row. Thus, the results demonstrated, with the exceptions of the nitrogen and potassium leaf content and dry mass in the sandy texture and the stalk diameter in the clay texture, there was no statistical difference between the doses of organomineral nitrogen as they did not differ from the additional mineral. Thus, it was indicated that organomineral nitrogen is just as efficient in maize culture as the source of mineral nitrogen.

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INTRODUCTION

Brazilian corn production estimated for the 2018/2019 harvest was over 100 million tons. Brazil is recognized as the third largest producer and second largest exporter of corn grains in the world. Corn is the second most produced cereal in the country and its use includes human and animal consumption, use in the bioenergy industry and export *commodity* (Conab, 2019). According to the National Fertilizer Diffusion Association (ANDA), in the accumulated period of 2018, Brazil used 35 million tons of NPK fertilizers, 80% of which came from imports. Over the past decade, the three macronutrients have provided a significant increase in fertilizer consumption. In the same period, the volume of nitrogen used by farmers was increased by 86% in the period from 2010 to 2018 (Anda, 2019).

Thus, Cruz *et al*. (2017) point out that a probable solution for reducing dependence on external nutrients is the use of organomineral fertilizers. The first definition of organomineral fertilizer came with Decree No. 86.955, of February 18, 1982, of Brazilian legislation, in which it defines organomineral fertilizer as the combination of organic and mineral fertilizers. Normative Instruction No. 25, of July 23, 2009, defined the specifications of organominerals that must present at least 8% of organic carbon; 80 mmolc kg^{-1} CTC; 10% of primary macronutrients alone (N, P, K) or in mixtures (NP, NK, PK or NPK); 5% of secondary macronutrients; and maximum humidity of 30% (Brasil, 2009). In this way it is possible for the rural producer to have the minimum guarantee for the product purchased. The manufacture of pelleted organomineral fertilizers is made using standardized techniques in equipment developed for this purpose, making a product with a high standard of pellet uniformity, with a hardness level of 8 kgf cm^3, respecting the current legislation on organomineral (Silva and Lana, 2018). Among the primary macronutrients is nitrogen, which plays a fundamental role in the high productivity of crops, being a prominent nutrient in plant nutrition. It is known that the efficiency of nitrogen use by plants is low, causing losses of nitrogen to the environment. Such losses are generally related to the volatility of ammonia (NH_3), nitrate leaching (NO_3^-) and the emission of nitrous oxide (N_2O) (Vieira, 2017). A possible way to reduce these losses is the use of organic mineral fertilizers, since the supply of organic matter to the soil improves its physical, chemical and biological conditions, thus improving the structure, aeration and water retention that, consequently, maintains or elevates the fertility of that soil. In relation to the environmental issue and sustainable development, the use of organic residues and wastes becomes feasible and effective, which would also contribute to reducing the use of mineral fertilizers (Malaquias and Santos, 2017). Elective strategies are necessary for brazilian agriculture to ensure sustainable agricultural production in the future (Withers *et al*., 2018).

Ulsenheimer *et al*. (2016) report that the use of this type of fertilizer is, without a doubt, viable for soybean, wheat and corn crops, both in agronomic and economic terms. Corn hybrids have undergone considerable changes in recent decades due to technological development. Through genetic improvement they became more precocious and productive. For this success, there was an increase in the dose of nitrogen fertilizer provided for the maize crop, resulting in the need to subdivise nitrogen fertilization (Sangoi *et al*., 2016). In the composition of the organic fraction of the organominerals, several raw materials are used, such as filter cake, poultry litter, cattle manure, cultural remains, industrial residues, sewage sludge, among others. Among these residues, the filter cake is composed of the mixture of ground bagasse and the decanting sludge from the sugar whitening process. Nolla *et al*. (2015) report that this residue has nutrients such as nitrogen, calcium, phosphorus and potassium, thus, occurring the release of phosphorus and nitrogen gradually through mineralization and by the action of microorganisms in the soil (Santos *et al*., 2011). The use of this compound as raw material for the manufacture of pelleted organomineral fertilizer is of high interest in the industry as it is of excellent quality to compose the organic part of this fertilizer. Thus, it is clear that the use of organomineral fertilizers is extremely advantageous from several points of view, since in addition to providing a better agronomic performance, it also reduces production costs. In this sense, there is a need to evaluate the response of pelletized organomineral fertilizers formulated with filter cake in corn as an alternative source of fertilizer or, in other words, to evaluate the efficiency of pelleted nitrogen organomineral fertilizer compared to mineral in different soil textures, in maize culture.

MATERIAL AND METHODS

Experiments: Two trials were conducted in the city of Uberlândia-MG: at the Syngenta experimental station, located on the BR 452 highway, km 141, at the geographic coordinate 18°55’26’’ S and 48°09’36’’ W. The soil of this place is classified as Dystrophic Red Latosol (Santos *et al*., 2018), with a clay texture, with the following composition: coarse sand 23.7%, fine sand 24.1%, silt 19.1% and 33.1% clay. The other experiment was carried out at the Juliagro experimental station, located at BR 365, km 640, at the geographic coordinate 18°54’05’’ S and 48°25’20’’ W. In this place the soil is classified as Dystrophic Red Latosol, sandy texture (Santos *et al*., 2018), with the following composition: 27.7% coarse sand, 52.5% fine sand, 7.6% silt and 12.2% clay. Samples of 0-20 cm depth were collected for chemical analysis before the installation of the experiments. The results are shown in Table 1 below:

The experimental design used was randomized blocks, with four replications, in a 2 x 5 + 2 factorial scheme, corresponding to two times of application in coverage in the development stage of corn (V2) and (V2 + V4), with 100% application in (V_2) and 50% in (V2) and 50% in (V4), five doses of organomineral fertilizer containing nitrogen, formula 25-00-00, proportional to 40, 60, 80, 100 and 120% of the conventional indication of nitrogen fertilizer. Two additional treatments were included with the recommended dose of 140 kg ha^{-1}, the first additional 100% applied in (V2) and the second additional 50% (V2) and 50% in (V4), using conventional 45% urea, as indicated in Table 2. The fertilization recommendation was made according to Alves *et al*. (1999) for productivity above 8000 kg ha^{-1} of grains. At sowing 500 kg ha^{-1} of the organomineral formula 04-20-05 (NPK) were distributed.

The experimental plot consisted of 6 lines with 0.5 m spacing between lines and 5 meters in length, totaling 15 m^2. The useful area of the plot was composed of the two central lines, discarding one meter from each end, totaling 3 m^2. The variations in rainfall were recorded in the automatic meteorological station of the National Institute of Meteorology - INMET - Uberlândia - MG, Figure 1. Sowing was carried out in the first half of November 2017, using seeds of hybrid corn Syngenta STATUS VIP3, for a population of 68,000 plants ha^{-1}, with the aid of a trawler seeder, pulled by a tractor with a line spacing of 0.5 cm and cutting depth of the ground 0.1 m deep. Weed control with herbicides and preventive pests and diseases were carried out using insecticides and fungicides. The composition of the organomineral fertilizer is shown in Table 3.

Results Evaluations: The response variables were made in six plants per plot, within the useful area, in the flowering stage (VT). The following were evaluated: Spad Index on the leaf below and opposite to the stalk; Stem diameter; Plant height; Leaf area suggested by Sangoi *et al*. (2007), Height of insertion of stalks. For leaf analysis, leaves were collected below and opposite the stalk for the determination of macro and micronutrient contents; fresh and dry mass; and accumulation of primary macronutrients in the entire plant; the determination of macro and micronutrients was carried out according to the methodology described by Silva (2009). Subsequently, the following were evaluated: stalk length, number of grains per row and number of rows per stalk, weight of 1000 grains and total productivity, with the grain moisture being corrected to 13%.

Statistical analysis: Preliminary tests of ANOVA assumptions regarding the normality of residues, homogeneity of variances and additivity of blocks at 1% probability were performed with the computer program SPSS 20.0. (Marôco, 2011). Once the assumptions were accepted, the data were submitted to analysis of variance (ANOVA), performed by the F test, at 5% probability. The doses of the organomineral were compared with the mineral by the Dunnett test at 0.05 significance with the computer program ASSISTAT (Silva and Azevedo, 2009) and regression analyzes by the SISVAR computer program (Ferreira, 2008).

RESULTS AND DISCUSSION

The results of the leaf content of macro and micronutrients (Table 4) showed that the doses of nitrogenous organomineral fertilizer applied to a sandy soil cover, regardless of the time of application, did not differ from the mineral supplement. Only the additions differed for the nitrogen content of the leaves, obtaining values of 22.2 g kg^{-1} in the application of 100% in stage V_2 and 18.9 g kg^{-1} when applied 50% V2 and 50% V4. However, for clayey soil, the organomineral fertilizer obtained higher levels of macro and micronutrients, a fact that may be reflecting the greater natural fertility of the experimental area (Table 1). According to the levels proposed by Martinez *et al.* (1999) and Oliveira (2004) for corn, the levels of nitrogen, sulfur and zinc are below the sufficiency range in the two soil textures, phosphorus and copper are below levels only in the sandy texture. Potassium, calcium, magnesium, iron and manganese are within the sufficiency range in the two soil textures (Martinez *et al*., 1999; Oliveira, 2004). During the conduct of the experiments, despite the content of some nutrients not being in accordance with those presented in the literature, no visible symptoms of deficiency were detected. The two sources of nitrogenous organomineral and mineral fertilizer did not stand out for the increase of the leaf content for macro and micronutrients, showing that the use of pelleted organomineral in coverage shows similar performance to the mineral source in the absorption of macro and micronutrient. Tiritan and Santos (2012) also observed similar responses between organomineral and mineral fertilization in corn cultivation.

The accumulation of nitrogen, phosphorus and potassium in the aerial part of the plants does not depend on the time of application, showing no differences with the increase of the organomineral doses in the clayey soil. In contrast, for a sandy texture, a significant difference in the accumulation of nitrogen was observed with the dose of 40% in the application in V2 and potassium in the doses of 100 and 120% of organomineral which presented contents in the plant lower than those of the additional minerals when applied in stages V2 and V4 (Table 5). Regarding the accumulation of nutrients in the grains, there was no significant difference in the two textures. Magela *et al.* (2019a) observed that doses equal to or less than the fertilization recommendation for the cultivation of corn were less efficient in the availability of potassium, corroborating with the data that emphasize that the organomineral fertilization in the different doses provided potassium contents lower than the mineral, a fact that can have occurred due to partial mineralization. Nitrogen is the nutrient responsible for the growth and development of plants and, consequently, for the increase in productivity. The nutrient is present in proteins and is a component of the chlorophyll molecule that is directly associated with photosynthetic activity and the translocation rate of assimilates (Büll, 1993). With emphasis on the corn crop, most of the nitrogen used to synthesize protein in the grain is absorbed until flowering, thus the amount of nitrogen stored in the plant tissues at the time of flowering is what defines the amount of nitrogen available to synthesize all nitrogen compounds in the plant (Mendes *et al*., 2012). In this context, Santos and Pereira (1994) found that plants with greater nitrogen accumulation obtain greater growth and development and, consequently, greater synthesis of carbohydrates. In this way, the plant becomes more able to allocate carbohydrates to the root system, making it more comprehensive and able to better take advantage of the available nitrogen, be it from the soil or from fertilizer. Dias (2020), comparing the use of organomineral and mineral nitrogen sources, observed that for any of the applied sources there will always be an increase in leaf nitrogen with increasing dose, indicating the equivalence between mineral and organomineral sources. These results indicate that organomineral fertilizers have potential and that they can be used as a cover in corn with equivalence to the results obtained with mineral fertilizers, as described by Barcelos *et al.* (2019), who obtained good results in the production of sorghum with the use of organomineral sources in fertilization. With the application of nitrogenous organomineral in the corn crop, the variables Spad and plant height were not influenced by the doses of organomineral, which showed similar results when applied to the clayey and sandy soil in the two application times. In addition, there was no difference between the application of the organomineral and the mineral supplement. However, for the stem diameter variable, there was a difference only between the application stages in the sandy texture (Table 6). The good development of the stem is an important physiological aspect, since the stem also functions as a storage structure for carbohydrates that will later be used in grain production. The difference evidenced between the application stages demonstrates the importance of splitting the application to improve absorption and increase the vegetative development of the plant (Carmo *et al*., 2012).

Regarding the other variables related to growth, the results corroborate that obtained by Silva *et al.* (2020), who, when evaluating an organomineral source in contrast to a mineral source, did not obtain significant differences between the sources for the growth variables in the corn crop. Additionally, they corroborate the study by Santos *et al.* (2011), who emphasize that organomineral sources can increase the absorption of nitrogen required by plants, significantly altering the chemical attributes of the soil, the availability of this nutrient, in addition to calcium, phosphorus and the levels of organic carbon, which leads to and demonstrates its equivalence to mineral fertilizer sources. Magela *et al.* (2019b), evaluating the effects of organomineral x mineral fertilization, found that organomineral fertilizers with biosolids and filter cake provided a height of the plant and stem diameter, at 35 DAS, higher than those provided by mineral fertilizers, confirming the efficiency of this group of fertilizers as obtained in the present study. These promising results can be attributed to the gradual release of nutrients, which is one of the main advantages of using organomineral material (Kominko *et al*., 2017). In sandy soil, there was a difference for the variables diameter, stalk length, grains per row and row per stalk, only between the application stages, with no differences between nitrogen organomineral doses, when compared with mineral nitrogen (Tabela 7). Regarding the stalk diameter in the clayey texture, there was a difference between the doses of organomineral in relation to the mineral source. In the application stage V2 + V4 the doses 60% and 80% were lower than the mineral source. Regarding the variable stalk length, the dose of 60% in stage V2 was lower than the mineral source, obtaining an average of 15.6 cm, while the mineral source had values of 16.9 cm in the stalk length in the clayey soil (Table 7).

Table 1. Chemical characterization of the soils in the experimental areas

Texture	pH /H_2O(1:2,5)	P meh^{-1}	K^+	S-SO_4	K^+	Ca^{+2}	Mg^{+2}	Al^{+2}	H+AL	SB	t	T
	-------------- --mg dm^3-------------------				--------------- cmol dm^3 ---------------							
Sandy	6.8	3.8	64	7	0.16	1.60	0.7	0.0	1.30	2.46	2.46	3.76
Clayey	5.8	29.1	148	14	0.38	3.0	1.3	0.0	3.10	4.68	4.68	7.78
	V	M		.M.O.	C.O			B	Cu	Fe	Mn	Zn
	--------%--------			----dag kg^{-1}----				------------mg dm^3--------------				
Sandy	65	0		1.4	0.8			0.27	0.4	15	2.7	0.8
Clayey	60	0		2.2	1.3			0.17	0.8	24	1.9	4.1

P, K=(HCl 0.05 mol L-1 + H2SO4 0.0125 mol L-1) P available (Mehlich-1 extractor); Ca, Mg, Al (KCl 1 mol L-1); H+Al= (pH 7.5 SMP Buffer Solution); SB= Sum of Bases ; t= Effective CTC; T= CTC at pH 7.0; V= Base saturation ; m= Aluminum Saturation (EMBRAPA, 1997), M.O = Colorimetric Method. B = (BaCl2.2H2O 0.0125% hot); Cu, Fe, Mn, Zn= (DTPA 0.005 mol L-1 + TEA 0.1 mol L-1 + CaCl2 0.01 mol L-1 a pH 7.3).

Table 2. Doses of organomineral nitrogen for top dressing fertilization in corn in different treatments

Fertilizer	Treatments	Percentage (%)[1]	Kg ha^{-1} N
Stage V2 100%			
46-00-00	V2 M (100%)	100	140
25-00-00	V2	40	56
25-00-00	V2	60	84
25-00-00	V2	80	112
25-00-00	V2	100	140
25-00-00	V2	120	168
Stages (V2 50%) + (V4 50%)			
46-00-00	V2 +V4 M (100%)	100	140
25-00-00	V2 +V4	40	56
25-00-00	V2+ V4	60	84
25-00-00	V2+ V4	80	112
25-00-00	V2+ V4	100	140
25-00-00	V2+ V4	120	168

[1]Percentages of nitrogen in relation to (100%) of the dose of 140 kg ha^{-1} according to Alves *et al.* (1999). Adc = Additional, M = Mineral, OM = Organomineral.

Table 3. Chemical composition of organomineral fertilizer on dry basis at 65º

Fertilizer	N - P – K	Urea	KCl
	04-20-05	25-00-00	00-00-30
	--------------------dag kg^{-1}------------------		
N	4	25	-
P_2O_5	20	-	-
K_2O	5	-	30
Ca	3.20	3.80	4.10
Mg	0.72	0.85	0.93
S	1.15	1.37	1.48
B	0.009	0.010	0.011
Cu	0.013	0.015	0.016
Fe	0.501	0.597	0.648
Mn	0.180	0.214	0.233
Zn	0.020	0.023	0.025
M.O	18.91	22.535	24.49
C/N	2/1	2/1	2/1
CTC	200	238	259
pH	5.2	-	-

According to Duete *et al.* (2009), the corn crop has higher levels of demand for nitrogen from the stage in which the plants have four to five expanded leaves. In contrast, studies conducted by Bender *et al.* (2013a) showed that between the V10 and V14 stages of corn, the highest nitrogen absorption rate occurs, a fact that proves that the availability of the nutrient must be guaranteed to the culture for a longer period, through the split of doses. However, it must be emphasized that nitrogen losses that occur due to volatilization can reduce the efficiency of nitrogen fertilization considerably. This fact is most important when the source of nitrogen is urea. For this one, the loss may be greater than other nitrogen sources, especially in times of irregular precipitation (Freire *et al*, 2010). In this way, the non-sufficiency of this nutrient in this growth phase can negatively influence the final production of this culture (Souza and Soratto, 2006). The possible occurrence of this fact may justify the results obtained mainly for S.D, S.L and G.R, which presented higher averages in sandy soil when the doses were applied in parcels in stages V2 and V4. Therefore, the nutrient became available for longer stages for the plant. This can be understood by paying attention to the fact that the sandy texture has a low buffering power of nutrients due to low fertility (Silva *et al*., 2020). Thus, the reactions of availability and absorption of nutrients by plants are more intense and occur quickly, mainly from mineral sources. In addition, according to Duete *et al*. (2009), in order to have a better efficiency of nitrogen application, the subdivision of the nitrogen source supply is indicated. With this, it is possible to minimize the losses by leaching, being that smaller amount of nitrogen will be subject to leaching, what avoids losses. When comparing organomineral fertilizers with soluble mineral sources, it is evident that the former has relatively less nutrient availability (Magela *et al*., 2019b). However, it can be said that the parceled organomineral source proved to be more efficient.

This may have occurred due to the progressive solubilization during the development period of the culture (Kiehl, 2008; Sosa-Rodrigues and García-Vivas, 2018). The explanation lies in the fact that these organomineral products have properties of slow release of nutrients in the system and improve the structural and biological condition of the soil, which facilitates the absorption of nutrients by the plant and which allows the availability of nitrogen during the development stages, mainly in flowering (Sosa-Rodrigues and García-Vivas, 2018). Similarly, Pérez *et al*. (2008) found that the incorporation of organic sources has different beneficial impacts on soil properties, according to the raw materials used in its preparation. Among these benefits, we can mention that organic nitrogen sources play an important role in the soil, such as nitrogen cycling, with additional benefits in soil quality, that is, increased organic matter, enzymatic activity, soil porosity and water retention (Ferraz-Almeida *et al*., 2020). There was no statistically significant difference for the time of application of fertilizers in the variables leaf area, stalk insertion, fresh weight, dry weight, weight of a thousand grains and productivity in the two soil textures (Table 8). Regarding the organomineral doses in the sandy texture soil, there was a decrease in dry mass in the doses of 40% and 60% when compared to the additional ones that differed for the dry mass, obtaining values of 6194 kg ha^{-1} in the application of 100% in stage V2 and 7452 kg ha^{-1} when applied 50% V2 and 50% V4. In clayey soil, there was no statistical difference between the doses of organomineral (Table 8).

Table 4. Leaf macronutrient and micronutrient content in pre-flowering corn in response to application of nitrogenous organomineral fertilizer, compared to different application times and mineral fertilizer (urea) in the 2017/2018 harvest.

Stage	%	N	P	K	Ca	Mg	S	Cu	Fe	Mn	Zn
		---------------------- Sandy ---------------------									
		g kg^{-1}						mg kg^{-1}			
		N	P	K	Ca	Mg	S	Cu	Fe	Mn	Zn
V2		20.7	1.47	22.1	3.25	1.77	0.76	5.55	68.3	44.3	6.98
V2+V4		21.1	1.41	22.1	2.98	1.71	0.83	4.89	70.5	48.0	7.48
V2	40	19.9	1.57	20.6	3.08	1.72	0.85	4.26	57.5	26.9	4.91
	60	20.0	1.33	20.4	3.08	1.63	0.70	3.28	63.1	51.1	5.91
	80	21.0	1.50	22.5	3.43	1.98	0.75	6.52	87.6	43.5	7.33
	100	21.9	1.58	23.4	3.10	1.82	0.77	6.97	69.9	50.8	9.53
	120	20.8	1.35	23.4	3.60	1.68	0.75	6.74	63.5	49.2	7.23
V2+4	40	20.8	1.50	23.1	3.37	1.80	0.83	5.59	51.5	47.0	7.59
	60	21.5	1.30	21.5	2.65	1.72	0.80	3.22	83.4	47.4	7.43
	80	20.5	1.45	20.8	2.85	1.55	0.82	5.03	76.6	37.4	6.45
	100	20.8	1.47	23.4	3.13	1.90	0.85	4.83	69.2	58.3	7.39
	120	21.7	1.35	21.8	2.90	1.58	0.87	5.79	71.8	49.8	8.54
Ad 100(+)		22.2*	1.43	22.6	2.92	1.85	0.76	0.83	78.1	44.7	5.67
Ad50+50(*)		18.9+	1.38	22.5	3.32	1.40	0.65	0.83	94.1	31.5	7.44
CV %		7.7	13.1	11.0	21.7	17.6	17.1	35.4	30.8	34.9	39.1
SW		0.093	0.159	0.095	0.091	0.086	0.683	0.844	0.607	0.652	0.015
LV		0.524	0.067	0.389	0.405	0.003	0.081	0.968	0.259	0.074	0.030
F`		0.306	0.387	0.284	0.142	0.027	0.064	0.372	0.982	0.133	0.002
		--------------------- Clayey ---------------------									
V2		24.3	1.75	24.3	3.15	1.76	0.83	7.39	89.2	56.6	16.32
V2+V4		24.4	1.86	25.2	3.29	1.75	0.87	8.13	64.6	65.3	18.63
V2	40	24.5	1.80	24.3	3.05	1.70	0.83	7.54	70.4	60.1	12.74
	60	24.0	1.85	24.6	3.30	1.78	0.82	7.72	130.2	58.1	16.20
	80	24.2	1.70	25.1	3.22	1.88	0.82	7.88	105.7	49.9	11.54
	100	24.2	1.65	24.4	3.12	1.82	0.80	5.22	70.0	63.4	16.79
	120	24.7	1.77	23.1	3.07	1.63	0.90	8.61	69.7	51.5	19.32
V2+4	40	24.7	1.85	25.0	3.37	1.85	0.87	8.10	84.2	67.8	16.87
	60	23.6	1.80	25.6	3.13	1.68	0.83	7.52	86.2	68.8	18.22
	80	24.9	1.90	25.8	3.35	1.78	0.92	7.59	75.9	60.6	20.87
	100	24.1	1.82	24.5	3.28	1.68	0.90	8.12	65.7	63.6	18.60
	120	24.8	1.95	25.1	3.35	1.75	0.85	9.29	90.8	65.4	18.60
Ad 100(+)		24.3	1.82	24.9	3.07	1.75	0.88	7.64	133.5	77.2	16.54
Ad50+50(*)		25.0	1.80	23.8	3.15	1.70	0.82	8.04	82.1	61.5	18.91
CV %		4.56	8.44	4.83	8.33	9.73	11.08	29.52	47.23	29.48	23.24
SW		0.096	0.027	0.347	0.527	0.989	0.550	0.040	0.014	0.481	0.311
LV		0.043	0.554	0.409	0.309	0.037	0.887	0.183	0.264	0.583	0.029
F`		0.806	0.891	0.886	0.933	0.913	0.847	0.046	0.373	0.035	0.006

* + Column averages differ from the Additional Mineral Urea by Dunnett's test at the level of 5% probability. The averages in the stage column differ by Tukey's test at 5% probability. SW, LV, F': assumptions of the Shapiro-Wilk, Levene and Block Additivity tests; values in bold indicate residues with normal distribution, homogeneous variances and additive effects.

Table 5. Accumulation of nitrogen (N), phosphorus (P) and potassium (K) in pre-flowering plants and corn grains in response to application of nitrogenous organomineral fertilizer in sandy and clayey soils, compared with different application times and mineral fertilizer (urea) in the 2017/2018 harvest.

%		--------------------- Sandy ---------------------					
		Plant			Grains		
		kg ha^{-1}			kg ha^{-1}		
		N	P	K	N	P	K
V2		110.7	8.2	146.2	119.5	15.3	34.7
V2+V4		113.7	9.2	140.7	121.8	16.3	36.6
	40	95.0+	7.3	137.4	100.4	12.4	33.0
	60	113.6	7.9	140.5	123.9	16.3	34.0
	80	118.5	9.0	135.4	126.3	17.7	40.0
	100	117.7	9.0	152.1	124.4	15.5	34.2
	120	108.6	8.0	165.5	122.3	14.5	32.5
	40	106.1	10.0	131.6*	115.9	14.4	33.0
	60	115.5	9.8	149.0	127.2	15.9	39.0
	80	113.1	9.1	147.4	120.1	17.8	40.7
	100	123.7	10.7	163.2	124.8	16.8	34.7
	120	110.2	6.4	112.3*	121.0	16.5	35.5
Ad 100(+)		124.1	9.2	141.1	114.9	14.5	37.9
Ad50+50(*)		110.1	11.4	191.0	124.1	15.2	35.9
CV %		12.4	26.8	19.2	14.8	24.0	19.9
SW		0.442	0.171	0.104	0.724	0.132	0.442
LV		0.218	0.001	0.053	0.270	0.393	0.345
F`		0.442	0.960	0.720	0.356	0.544	0.866
		--------------------- Clayey ---------------------					
V2		132.5a	11.6a	225.9a	178.5a	58.9	58.8
V2+V4		134.0a	11.9a	227.3a	183.8a	59.3	57.6
V2	40	136.2	13.7	247.7	175.5	61.7	60.2
	60	130.6	11.6	219.5	182.5	63.1	62.9
	80	131.6	10.9	217.1	177.3	58.3	59.1
	100	131.2	10.4	225.2	175.3	56.7	57.5
	120	132.6	11.2	219.8	181.8	54.9	54.5
V2+V4	40	128.5	11.6	214.2	186.0	53.5	52.7
	60	135.3	11.1	234.1	181.5	58.3	54.9
	80	129.5	12.6	218.6	178.4	58.9	58.2
	100	138.3	12.2	228.0	192.8	65.5	61.8
	120	138.2	11.9	241.7	180.5	60.5	60.6
Ad 100(+)		123.5	12.2	209.6	195.2	71.2	67.5
Ad50+50(*)		133.9	12.4	231.6	194.3	71.8	65.2
CV %		9.0	13.1	9.1	7.9	17.7	13.2
SW		0.499	0.097	0.530	0.202	0.420	0.720
LV		0.521	0.277	0.376	0.306	0.523	0.492
F`		0.381	0.428	0.579	0.274	0.045	0.011

* + Column averages differ from the Additional Mineral Urea by Dunnett's test at the level of 5% probability. The averages in the stage column differ by the Tukey test at 5% probability. SW, LV, F ': assumptions of the Shapiro-Wilk, Levene and Block Additivity tests; values in bold indicate residues with normal distribution, homogeneous variances and additive effects.

Table 6. Spad index, plant height and stem diameter in pre-flowering corn plants, cultivated with nitrogenous organomineral fertilizer in sandy and clayey soils, compared to different application times and mineral fertilizer (urea) in the 2017/2018 harvest

Texture		Sandy			Clayey		
Stages	%	Spad	Height (m)	Stem (mm)	Spad	Height (m)	Stem (mm)
V2		53.9	2.46	20.8 b	55.3	2.54	22.2
V2+V4		54.8	2.49	21.5 a	55.4	2.57	22.6
V2	40	50.7	2.44	55.2	55.2	2.59	22.4
	60	53.5	2.40	55.0	55.0	2.47	22.0
	80	53.4	2.45	55.5	55.5	2.54	22.2
	100	55.3	2.47	54.8	54.8	2.53	22.4
	120	56.9	2.55	55.8	55.8	2.58	22.2
V2+V4	40	51.9	2.51	56.1	56.1	2.58	22.2
	60	55.1	2.48	56.1	56.1	2.58	23.1
	80	54.9	2.45	55.2	55.2	2.53	22.4
	100	55.7	2.50	54.5	54.5	2.59	22.2
	120	56.2	2.50	55.2	55.2	2.58	23.1
Ad 100(+)		55.3	2.42	22.0	55.6	2.59	21.4
Ad50+50(*)		56.5	2.51	22.0	56.8	2.49	23.1
CV %		4.43	4.20	4.85	2.81	3.59	4.10
SW		0.563	0.023	0.060	0.563	0.023	0.060
LV		0.854	0.104	0.276	0.854	0.104	0.276
F`		0.127	0.005	0.287	0.127	0.05	0.287

* + Column averages differ from the Additional Mineral Urea by Dunnett's test at the level of 5% probability. The averages in the stage column differ by the Tukey test at 5% probability. SW, LV, F ': assumptions of the Shapiro-Wilk, Levene and Block Additivity tests; values in bold indicate residues with normal distribution, homogeneous variances and additive effects

Table 7. Average of stalk diameter (S.D), stalk length (S.L), number of grains per row (G.R.) and number of rows per stalk (R.S) of plants submitted to doses of nitrogenous organomineral fertilizer, compared to application seasons and mineral fertilizer (urea) in clayey and sandy soil in the 2017/2018 harvest

Texture		Sandy				Clayey			
Stages	%	S.D (mm)	S.L (cm)	G.R	R.S	S.D (mm)	S.L (cm)	G.R	R.S
V2		48.2b	15.0b	29.6b	16.7	53.1	16.0	17.1	31.6
V2+V4		49.7a	15.5a	30.6a	17.1	54.3	16.4	17.1	32.5
V2	40	46.4	13.5	26.8	16.8	53.1	16.0	17.1	31.9
	60	46.6	14.7	28.5	16.4	53.0	15.6 +	17.3	30.5
	80	49.4	16.1	32.3	16.5	53.3	15.9	17.3	31.9
	100	49.0	15.4	30.1	16.8	53.0	16.5	16.8	32.4
	120	49.5	15.4	30.5	17.1	53.2	16.1	17.1	31.3
V2+4	40	49.4	15.5	30.5	16.8	53.8	15.9	17.3	31.8
	60	49.3	16.0	31.5	17.0	52.3 +	16.0	17.4	32.3
	80	49.6	15.7	31.1	17.3	52.5 +	15.9	17.2	31.6
	100	50.5	15.3	30.2	17.1	54.4	17.2	17.3	34.3
	120	49.7	15.0	29.9	17.1	53.7	16.5	17.7	31.7
Ad 100(+)		48.5	15.0	29.8	17.3	54.7	16.9	17.5	33.3
Ad50+50(*)		49.2	15.8	31.9	16.7	54.3	16.4	17.1	32.5
CV %		2.95	4.55	5.12	3.60	1.58	3.51	2.81	4.01
SW		0.037	0.190	0.354	0.646	0.037	0.190	0.354	0.646
LV		0.113	0.011	0.317	0.022	0.113	0.011	0.317	0.022
F`		0.065	0.257	0.169	0.573	0.065	0.257	0.169	0.573

* + Column averages differ from the Additional Mineral Urea by Dunnett's test at the level of 5% probability. The averages in the stage column differ by the Tukey test at 5% probability. SW, LV, F ': assumptions of the Shapiro-Wilk, Levene and Block Additivity tests; values in bold indicate residues with normal distribution, homogeneous variances and additive effects.

Table 8. Averages of leaf area (L.A), fresh mass (F.M), dry mass (D.M), weight of a thousand grains (WTG) and productivity (Prod) of plants subjected to doses of nitrogenous organomineral fertilizer, compared to application seasons and mineral fertilizer (urea) in clayey and sandy soil in the 2017/2018 harvest

Texture		Sandy					Clayey				
Stages	%	L.A (cm²)	F.M (kg ha⁻¹)	D.M (kg ha⁻¹)	W.T.G (g)	PROD. (kg ha⁻¹)	L.A (cm²)	F.M (kg ha⁻¹)	D.M (kg ha⁻¹)	W.T.G *g)	PROD. (kg ha⁻¹)
V2		7292	44977	6453	294	10376	7632	59663	7464	343	13396
V2+V4		7462	46227	6533	294	10566	7501	60314	7451	341	13362
V2	40	6975	41501	5865*	276	8924	7666	61179	7716	343	13003
	60	7288	44008	6105*	290	10119	7364	58813	7251	331	12268
	80	7397	45708	6774	289	11383	7618	61053	7604	338	12857
	100	7121	43328	6326	302	10450	7878	58415	7319	351	13559
	120	7680	50341	7194	312	11001	7635	58855	7433	341	12823
V2+V4	40	7029	44348.8	6215	290	10526	7236	55819	6931.7	337	12809
	60	7811	45836.3	6565	294	10690	7693	61074	7428.4	334	12947
	80	7310	46070.0	6639	289	10558	7828	60015	7335.1	342	12905
	100	7686	49130.0	7015	289	10592	7449	61305	7600.8	348	13756
	120	7472	45751.3	6232	311	10463	7297	63356	7962.4	354	13053
Ad 100(+)		7432	44348	6194*	300	9727	7563	55756	6829	353	13094
Ad50+50(*)		7871	50596	7452	292	10420	8014	60739	7632	343	12902
CV %		5.62	9.95	9.75	6.72	10.54	6.07	6.82	7.77	4.17	6.54
SW		0.576	0.334	0.999	0.454	0.036	0.576	0.999	0.334	0.591	0.942
LV		0.031	0.221	0.162	0.093	0.394	0.031	0.162	0.221	0.409	0.744
F`		0.220	0.647	0.645	0.650	0.805	0.220	0.645	0.647	0.142	0.280

* + Column averages differ from the Additional Mineral Urea by Dunnett's test at the level of 5% probability. The averages in the stage column differ by the Tukey test at 5% probability. SW, LV, F ': assumptions of the Shapiro-Wilk, Levene and Block Additivity tests; values in bold indicate residues with normal distribution, homogeneous variances and additive effects.

In the clayey texture, the two types of fertilizer had the same behavior in the evaluated variables showing that the organomineral supplied the plant's demand. This event can be explained because organomineral fertilization is a notable source of nutrients, especially nitrogen, phosphorus, sulfur and micronutrients, this being the only form of nitrogen conservation that does not volatilize in the soil (Pires and Junqueira, 2001), so the plants absorb according to their needs during the production cycle. Magela (2019b) emphasizes that, in the corn harvest, the use of biosolids-based fertilizer led to an increase in the green mass of aerial parts using the source with filter cake, regardless of the dose used. Regarding dry mass, several authors state that the increase in dry mass production is proportional to the nitrogen fertilization dose, corroborating the results found here, since they showed proportionality to the available nitrogen doses (Fernandes and Libardi, 2012; Rimski-Korsakov; Rubio; Lavado, 2012). The results showing an increase and accumulation of dry mass of plants is emphasized by Faria (2014) as an important factor in the production cycle, being extremely linked to soil management and conservation. In fact, after harvesting the grains, the crop remains in the production area and promotes soil protection, decreasing water erosion and evaporation, increasing the available water content, favoring soil microbiota, recycling and diffusion of nutrients, especially immovable ones (P and Zn).

For the productivity variable, it was observed that organomineral fertilization did not show any significant difference compared to mineral fertilization. The use of nitrogenous organomineral fertilizer, even in the smallest doses, was sufficient for the corn crop to achieve good productivity rates. This indicates that the nitrogen source organomineral had satisfactory efficiency in supplying nitrogen to the plants. However, it is acceptable to infer that the plasticity of the corn hybrid used and the greater genotypic efficiency in the absorption of the nutrient also cooperated to level the responses obtained with nitrogen doses (Silva *et al.*, 2020). Demonstrating similarity with the results, Silva *et al.* (2019), analyzing the variables together, related to the production of the bean culture (number of pods, number of grains, number of weight of a thousand grains), found the efficiency in the use of organomineral fertilizer based on biosolids, verifying that even without showing statistical differences, these factors were superior to mineral fertilizer. In contrast, Possamai (2016) reports that organomineral fertilization does not bring results superior to chemical fertilization when formulations that are said to be equivalent in corn are used, thus, the plants with chemical fertilization obtained a higher stature than the other treatments and produced an average of 1368 kg ha^{-1} more than the organomineral fertilization, thus showing that the chemical fertilization was more advantageous. However, to analyze the action of organomineral fertilizers, it is necessary to evaluate its use as a soil conditioner for several years because it has slow nutrient availability. The results obtained in the present study corroborate with Galvão (1998) in an experiment carried out for several years in the culture of corn, where the yield with organomineral fertilization was 24.61% higher than mineral fertilization, proving that the continuous use of organic compost improved fertility soil over the years. Like Silva *et al.* (2007) who also found that the continuous use of organomineral fertilization in corn for several years causes significant increases in grain production.

Conclusion

- The partial application of nitrogenous organomineral fertilizer in the corn crop was not influenced by the soil texture, which did not influence most of the variables analyzed (Spad index, number of rows per stalk, plant height, stem diameter, leaf area, fresh mass, dry mass, weight of a thousand grains and productivity).
- In relation to the time of application, the split of the application in V2 (50%) + V4 (50%) of the corn crop showed better increments for stem and stalk diameter, stalk length and number of grains per row.
- With the exception of the foliar nitrogen and potassium content, as well as the dry mass in the sandy texture and stalk diameter in the clay texture, there was no

statistically significant difference between the doses of nitrogenous organomineral as they did not differ from the mineral supplement. Thus, the nitrogenous organomineral is as efficient as the nitrogenous mineral source.

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