

Agronomic efficiency of organomineral fertilizer in onion cultivation

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Abstract

Onions has high nutritional and nutraceutical value. In the last decade the bulbs have gained increasing relevance due their compounds linked to anti-cancer effects. The fertilization management is relevant to this crop because the mineral's influence beyond productivity, interfering in several aspects of quality. Organic sources despite available, adoption is still cautious and seen as an expense, rather than investment in soil quality. Therefore, the objective was to evaluate the use of organomineral fertilizer on the development and productivity of Akamaru hybrid. The experiment was carried out in Cristalina-GO, in a randomized block design, with 4 replications and 5 treatments: organomineral fertilizer (NPK) with the formula 02-20-05. The rates were adjusted to approximately the same amounts, where 3,680 kg ha⁻¹ was considered the 100% rate, 2,944 kg ha⁻¹ as 80%, 2,208 kg ha⁻¹ as 60% and 1,472 kg ha⁻¹ as 40% of the rate established. The rate of 2,300 kg ha⁻¹ of the formulated 03-35-06 referred to 100% of the mineral source. The total yield of onion was not affected when the organomineral source was used, therefore, it is a viable source for use in onion culture. A rate reduction of up to 20% of the recommended mineral rate allows good performance (85.5 t ha⁻¹), with 7.5 t ha⁻¹ higher than the 60% reduction of the recommended rate.

Keywords: *Allium cepa* L., fertilizer sources, organic matter, plant nutrition

Introduction

Onion (*Allium cepa* L.) is one of the most important bulb crops cultivated in the world, growing in a wide range of climatic conditions. The plant is used in dishes, soups, sandwiches and salad. The nutrition value includes proteins, starch, sugars and some vitamins. Besides its nutritional, onion show medical applications, specially to prevent cancer (El-Sherbeny et al., 2022).

The nutritional aspect is particularly important for bulbs due to the mineral's influence on their quality. In many cases, the fertilization process and the nutritional status interfere not only in productivity, but also the size, weight, color of the bulb, post-harvest conservation and resistance of plants to pests and diseases (Kurtz et al., 2018).

The excessive use of chemical products via fertilizers and phytosanitary has been a reality in several regions of Brazil. To minimize the negative impacts on

crops and ensure the sustainability of ecosystems, the use of new techniques that rationalize the use of inputs by farmers are necessary to increase income from the agricultural activity, providing good practices and production of safe food (Menezes Júnior et al., 2016; Menezes Júnior et al., 2018).

Organominerals (OM), biofertilizers (BF) and biostimulants (BS) have a promising effect on nutrient availability (Morya et al., 2018), being an interesting tool for crop fertilization. The OM/BF/BS product market encompasses algae extracts, organic acids, beneficial or so-called efficient microorganisms (bacteria and fungi), amino acids, extracts from the metabolism of microorganisms, biochar and concentrated enzymes (Sible et al., 2021).

The addition of organic components in the cultivation system allows improvements in the performance of plants against environmental stressors,

being the investment with the applications justifiable and with a high potential for return (Kistner et al., 2018).

There is a growing interest in proposals and products that bring ways to optimize the use of resources and maximize fertilization, shifting the focus from the amount of soluble nutrient to be made available to the efficiency of the use of nutrients by the environment (considering the soil, the life of the soil and its dynamics and plants). Thus, the application of compost associated with materials of organic origin has been shown to be significantly favorable to soil fertility due to the increase in organic matter and nutrients such as: N, P, K, Fe, Mn e Zn (El-Dissoky; Gahwash, 2018).

According to (Shura et al., 2022) soil macronutrients need to be optimized with the consideration of improving the production of onion. The use of OM can expand this scenario, providing new forms of fertilization and helping the onion production chain. Therefore, the objective was to evaluate the use of organomineral fertilizer on the development and productivity of Akamaru hybrid.

Material And Methods

The experiment was carried out at Wehrmann Agrícola in Cristalina-GO, under geographic coordinates 17° 02' 45" south latitude and 47° 45' 24" west longitude and 980 m altitude.

The period of the experiment was from May 5, 2017 to September 21, 2017, and the genetic used was the Akamaru hybrid, with an average cycle of 120 to 130 days, with rounded bulbs and brownish-yellow skin color.

The soils at the site are medium-textured Red-Yellow Latosol type (Embrapa, 2018). The relief is gently undulating to flat. The average annual precipitation and temperature are 1300 mm and 20.9 °C, respectively. The chemical characterization of the soil is shown in (Table 1).

The experiment was carried out in a randomized block design (DBC), with four replications, and 5 treatments, with the control fertilized with 2.300 kg ha⁻¹ of the formulated 03-35-06, this rate being considered 100% of the recommended fertilizer rate by mineral (M) source. The organomineral (OM) treatments were adjusted to approximately the same amounts of NPK using the formula

02-20-05 as source, where 3.680 kg ha⁻¹ was considered the 100% rate, 2.944 kg ha⁻¹ as 80%, 2.208 kg ha⁻¹ as 60% and 1472 kg ha⁻¹ as 40% of the established rate.

The area of all treatments received 1 t ha⁻¹ of superphosphate (18% P₂O₅) at pre-planting and coverage fertilization equal for all treatments. The cultivation and phytosanitary control were the ones commonly used in the onion crop.

Sowing was done directly in the beds with 12 cm spacing within the double lines and 18 cm between the double lines. Were sown 23 seeds per meter, with a population of 255.000 plants ha⁻¹.

The experimental unit consisted of a 2.5 m long bed with four double planting lines, the two central doubles being considered a useful plot, excluding the first and last plant of each double line.

At 49, 82, 96 and 107 days after planting (DAP) measurements of the SPAD index were carried out in order to identify the nutritional condition of the plants in relation to leaf nitrogen content, using the indirect chlorophyll meter SPAD-502 (Soil Plant Analysis Development). The evaluations were carried out in the upper third, on the youngest fully developed leaf, with 20 plants per plot.

At 82 DAP, leaves were also collected to analyze the nutritional status of the plants. The youngest fully developed leaf was collected, and 3 leaves were collected per plot. The contents of macronutrients (N, P, K, S, Ca, Mg) and micronutrients (Mn, Cu, B, Zn and Fe) where evaluated according to the methodology recommended by (CFSEMG, 1999).

The harvest was carried out at 139 DAP and the onion was submitted to the curing process for 15 days. After curing, the bulbs were classified into types 1 (Class 1-C1), 2 (C2), 3 (C3), 4 (C4), lollipop and discard (Table 2). Class 3 is the one with the best quality bulbs, according to the national market.

Each class was weighed and the yield per hectare was estimated. The variables were submitted to analysis of variance and the characteristics that were significant by the F test at 5% of probability were compared by the Tukey test also at the level of 5% of probability.

Table 1. Soil chemical analyses before the experiment implementation in Cristalina-GO at 0-20 cm depth

	pH (H ₂ O)	pH(CaCl ₂)	P	K	S	K	Ca	Mg	Al
				mg dm ⁻³			cmolc dm ⁻³		
0-20 cm	5.55	5.21	29.54	229.71	76.84	0.30	3.76	1.20	<0.1
	B	Zn	Fe	Mn	Cu	Potential acidity	CEC	V	
			mg dm ⁻³			cmolc dm ⁻³		%	
0-20 cm	1.20	6.30	26.43	25.23	1.17	5.52	9.43	58.91	

CEC: effective cation exchange capacity; V (%): percentage by base saturation. Soil P, K [HCl 0.05 mol L⁻¹ + H₂SO₄ 0.025 mol L⁻¹]; Al, Ca, Mg = [KCl mol L⁻¹]; B = [BaCl₂·2H₂O a 0.125% hot water]; Cu, Fe, Mn, Zn = [DTPA 0.005 mol L⁻¹+CaCl 0.01 mol L⁻¹ + TEA 0.1 mol L⁻¹ a pH 7.3]; S-SO₄²⁻ = Ca(H₂PO₄) 0.01 mol L⁻¹.

Table 2. Tolerances for Onion Quality Categories (%), Cristalina-GO

Defects Category	C1	C2	C3	C4
	%			
Thick stalk	0	3	5	20
Sprouted	0	0	3	10
Rot	0	0	1	1
Musty	2	3	5	5
Black spot	2	3	5	5
Total bass	2	5	10	20
Total weightless	5	10	15	100
Grand total	5	10	15	100

Results and Discussion

The SPAD index values in the four evaluations along the onion cycle are shown in (Table 3). It was observed significant difference between the leaf indices, correlated to N, for the fertilizations in the first and last evaluation.

At 49 DAP, the highest SPAD indices were observed in fertilizations with higher nutrient contents (100% M, 100% OM and 80% OM), which varied between 72 and 77. At 107 DAP, the highest SPAD indices referred to fertilizations with 100% OM and 80% OM.

The SPAD index can be used as an indication of N application and is related to the chlorophyll content in the plant, thus expressing the nitrogen nutritional status in a specific phase of the crop cycle (Silva et al., 2011). Information regarding the availability of N in the soil allows directing future fertilization and management (Silva et al., 2011).

Nutrient reductions of up to 20% in the rate with organomineral source (100% OM and 80% OM) showed the same behavior as the application of 100% M regarding the SPAD index in all evaluations.

According to (Vidigal et al., 2009) the critical values of SPAD index for the onion crop were 61.94, 65.92 and 63.93, at the base, in the middle and at the apex of the leaf, respectively. These values corroborate with the indices found in the present study, which show the good nutritional status of the plants, since the indices ranged from 62.84 to 77.47 (Table 3) and are confirmed with the foliar contents observed in the table 4, which are within the ideal range.

Table 3. Spad index, on different days after planting (DAP), throughout the onion development cycle

Treatments	49 DAP	82 DAP	96 DAP	107 DAP
100% (M)	77.47 a	61.59 a	63.03 a	62.96 ab
100% (OM)	72.49 ab	63.89 a	63.27 a	64.00 a
80% (OM)	76.14 ab	63.72 a	61.69 a	68.40 a
60% (OM)	62.84 c	63.60 a	63.13 a	65.13 ab
40% (OM)	66.78 bc	63.73 a	62.52 a	63.40 b
CV(%)	3.5	4.80	3.00	7.28

CV: coefficient of variation.

Analyzing the foliar contents of macro and micronutrients, it was observed no significant difference between the fertilizers, mineral or organomineral, for any of the macro and micronutrients studied (Table 4).

The sulfur content (S) was lower than the ideal range considered in the literature by several authors (Caldwell et al., 1994; Malavolta et al., 1997), when the plants were fertilized with 100% OM and Mn when the plants were fertilized with 80% OM.

The onion is an S demanding plant, and this nutrient is usually third or fourth in decreasing order of accumulation. The amount of S-based compounds determines the pungency of the onion (Malavolta et al., 1997). S is an important constituent of some amino acids, such as cystine, methionine, cysteine and tryptophan and a precursor of volatile sulfur compounds responsible for onions aroma (Trani et al., 2014).

In recent seasons, especially since 2013 (Kurtz, 2013), several onion crops in the Alto Vale do Itajaí-SC region showed symptoms of S deficiency. S deficiency usually occurs in soils with low organic matter content, sandy and intensively cultivated soils, without nutrient replacement and with the cultivation of demanding species.

In no-till areas (seeding in a permanent field), the problem has occurred more frequently, causing a reduction in the population due to plant death (Kurtz, et al., 2018). Studies with S replacement observed optimal sulphur content in bulbs was restricted to addition of sulphur up to 40 kg ha⁻¹ (Mondal et al., 2020). Additional sulphur supply decrease in response probably due to the supply of sulphur partly through the native soil sulphur and irrigation water (Kar et al., 2022).

Przygocka-Cyna et al. (2020) identified relationship between N and S, in high rates of N onion plants can reduce S uptake and consequently decrease bulb pungency. These authors emphasized the impact of N and S on onion growth, yield, and bioactive compounds highlighted the necessity to optimize the doses of both nutrients. The proportion of N that becomes available in organic fertilizers increase with decreasing carbon:N ratio (Lazicki et al., 2020). Therefore, understanding the relationship between the rate of N release (source dependent) and the amount applied helps to avoid S deficiency.

A content higher than the ideal range was found only for the micronutrient Zn, in all evaluated fertilizations. The other nutrients presented levels within the recommended range for onion cultivation, according to (Caldwell et al., 1994).

Table 4. Nutritional status of onion plants

Treatments	g kg ⁻¹					mg kg ⁻¹					
	N	P	K	S	Ca	Mg	Cu	Fe	Mn	Zn	B
100% (M)	35.14	3.12	21.6	5.52	14.9	3.44	15.67	218.64	32.88	76.94	26.708
100% (OM)	36.54	2.96	22.3	4.76	14.42	3.12	14.766	192.9	37.48	73.3	25.842
80% (OM)	35.14	3.1	22.3	5.46	15.68	3.44	15.748	210.62	28.78	78.74	25.342
60% (OM)	35.56	3.1	22.0	5.8	13.82	2.98	15.432	205.14	32.06	77.6	25.646
40% (OM)	36.26	2.98	21.1	5.8	15.58	3.16	13.192	187.88	33.2	78.88	25.434
ideal range*	19-40	2-4	20-50	5-10	9-35	2-5	6-20	60-300	30-200	10-50	10-50

* Recommendation according to Caldwell et al. (1994).

As for onion yield, and within the analyzed bulb classes, the highest bulb yield was obtained in class 3, ranging from 57.5 t ha⁻¹ (80% OM) to 55.6 t ha⁻¹ (100% M), with a variation of 3.4% between the highest and lowest yield, not differing statistically.

Menezes Junior & Kurtz, (2016) observed in 2011, in a population of 300 to 400 thousand plants ha⁻¹, maximum productivity of C3 bulbs of 48.1 and 36.7 t ha⁻¹ and in populations of 500 to 600 thousand plants ha⁻¹ yields of 25.2 and 14.7 t ha⁻¹ at the highest dose of N applied (200 kg ha⁻¹ of N).

In the present study, in a population of 255 thousand plants ha⁻¹, higher yields were observed than those found by Menezes (Junior and Kurtz, 2016). It can be related to the differences between the regions studied (climatic conditions and management) and the plant population, which configures these factors as important factors for optimizing onion production.

In the other analyzed bulb classes (C1, C2 and C4) significant differences were observed. The highest yield of class C1 was related to fertilization with 100% M (1.9 t ha⁻¹), being 42.1 and 63.2% higher than fertilization with 100% and 40% OM, respectively (**Table 5**).

In C2, the highest yield related to 80% OM (18 t ha⁻¹) and the lowest yield at the rate of 100% OM (13.5 t ha⁻¹). In C4, the highest yield was obtained at the rate of 100% OM, with 13.9 t ha⁻¹ and the lowest at the rate of 40% OM, with 3.2 t ha⁻¹ (Table 5).

When the plants received 80% OM, there was a higher yield of lollipop-type bulbs (0.9 t ha⁻¹), a type of lower value in the onion market due to its low caliber. In this same fertilization (80% OM), there was also a highlight

Table 5. Onion bulb yield in different classes (1, 2, 3 and 4) and total yield, as a function of organomineral fertilization

Treatments	C1	C2	C3	C4	Lollipop	Discard	Total yield
	t ha ⁻¹						
100% (M)	1.9 a	16.3 a	55.6 a	7.3 b	0.3 cd	5.1 c	81.5 ab
100% (OM)	1.1 b	13.5 b	57.0 a	13.9 a	0.1 d	3.3 ab	85.8 a
80% (OM)	1.1 b	18.0 a	57.5 a	7.8 b	0.9 a	2.7 a	85.5 a
60% (OM)	1.0 b	16.0 ab	57.3 a	6.3 b	0.4 bc	4.0 b	81.2 ab
40% (OM)	0.7 b	17.1 a	56.2 a	3.2 c	0.5 b	2.9 ab	78.0 b
CV (%)	17.4	6.9	5.2	14.7	20.5	12.8	3.2

CV: coefficient of variation.

in relation to discard, presenting the lowest rate (2.7 t ha⁻¹) of discarded bulbs, with the amount of discarded bulbs being 88.8 and 22.2% respectively, lower than the fertilization with 100% M and 100% OM (Table 5).

For total yield, it was noted that the reduction in the amount of nutrients via fertilizer (OM) of up to 60% (40% OM) did not differ from the application of 100% M (Table 5). However, 100% and 80% OM were higher than 40% OM, not differing from the others.

Menezes Júnior & Higashikawa, (2017), studying mineral, organic and organomineral fertilizers, found no difference in onion productivity between the fertilizer sources used. Santos et al., (2017) found a positive response when applying a foliar fertilizer with components from organic sources (amino acids). The results obtained by the authors referred to an increase in the production of C3 and C4 class bulbs of the Cristalina onion hybrid.

Díaz-Pérez et al., (2021) found plants and bulb yields growing with organic fertilizer alone or mixed (50% organic N; 50% inorganic N) comparable to those grown with chemical fertilizer, which corroborates to the results of the present study.

The effects of organic fertilizers on onion yield are inconsistent across studies and it can be better, worse or indifferent (Kazmierczak et al., 2021). These inconsistent results could be related to large variation that occurs between organic sources and their dynamics in the soil, that make it difficult to establish a more assertive indication regarding the source and appropriate rate, as well as to understand the complex behavior of organic molecules in agroecosystems.

However, the benefits are off course well understood, the organic components present in the organomineral fertilizer provide food for soil microbiota and promote an increase in soil total porosity and soil water holding capacity (Díaz-Pérez et al., (2021)). According to Geisseler et al., (2022) most of the N in organic fertilizers and composts is in the organic form and needs to be first mineralized to plant-available ammonium and oxidized to nitrate by soil microorganisms, which highlights the impact of this fertilizer category on physical, chemical and biological characteristics.

Due to the degree of interaction between several factors and its complexity, there is still much to be understood and studied in this area, especially for demanding and highly responsive crops, such as onion.

Conclusion

The total yield of onion was not affected when the organomineral source was used, therefore, it is a viable source for use in onion culture.

A rate reduction up to 20% of the recommended mineral rate allows good performance (85.5 t ha⁻¹), with 7.5 t ha⁻¹ higher than the 60% reduction of the recommended rate.

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