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Soil organomineral fertilization in garlic crop

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Abstract

Garlic (*Allium sativum*) stands out in the culinary and alternative medicine of many people. The crop is very responsive to adding fertilizers. Commonly the sources used are minerals, but in the last decade the demand for combining these with organic ones has grown, making up the organomineral fertilizers. Due to benefits in the soil and the consequent effect on crops yield, organominerals have been associated as a promising alternative in nutritional management. In this context, the objective was to evaluate the production of garlic under the application of organomineral fertilizer on soil. Quiteria was the variety used in the study. The design was a randomized complete block with five treatments: control (mineral fertilizer in the dose of 100% of the recommendation for the standard crop of the property) and four concentrations of the organomineral fertilizer (100; 80; 60 and 40% of the recommendation for the crop). The percentage of marketable garlic and SPAD index showed no significant difference between the fertilizations evaluated. It was concluded that the use of organomineral fertilizer in the rate of 80% offers the same performance in productivity compared to the 100% mineral, in addition to providing a higher quality in national garlic, as it offers a lower percentage of cull garlic bulbs, adding value in the national garlic chain.

Keywords: *Allium sativum* L., chlorophyll, organic matter, yield

Introduction

Garlic (*Allium sativum* L.) is one of the most appreciated and consumed vegetable species worldwide. Bulbs are used as a source of accentuating flavor in foods and to promote health, mainly due to antioxidant properties, phenolic compounds and high levels of organosulfur compounds (Abdel-Wahhab et al., 2012; Barboza et al., 2020).

According to ANAPA (2017), the cultivation of garlic is of great economic importance in Brazil, with about 11,334 hectares cultivated by the country and a production of 136,000 tons. Of this production, 80% is dedicated to consumption and the remaining 20% is for planting or those unfit for the market.

Soil care is essential for the proper development of any crop. As for garlic, fertility levels must remain adequate for optimal growth, especially in relation to the amount of nitrogen, which is the most important nutrient for determining the productivity and quality of bulbs and bulbils (Fernandes et al., 2011).

Studies show that the amount of chlorophyll in the leaf is directly related to the nitrogen present in it. Whereas the main determining factor for the photosynthetic activity is the leaf chlorophyll content (Olfati et al., 2016), determining the amount of N with apparatus capable of assessing the nutritional status of the plants in real time, quickly and low cost, as SPAD (Soil Plant Analysis Development), allows to adjust the fertilization according to the state of the plant and make the fertilization of garlic more efficient.

Fertilizations in the garlic crop are heavy, because at high rates it responds to production. However, the high amounts of nutrients inputs from fertilizers, can cause remarkable environmental impacts (Giuseppe et al., 2016).

The combination of organic and mineral fertilizers

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forming organominerals has been a promising alternative to reduce environmental impacts and meet the high demand for garlic. Organic fractions of organominerals applied to the soil promote a slow release of nutrients, which minimizes the negative effects of nutrient loss through leaching (Xiang et al., 2018; Nayak et al., 2019).

The addition of organic fractions in nutritional management is a long-term strategic, due to technological advantages in relation to application of traditional chemical management. This is because recycling of substances, reduced toxicity in food chain and control of plant health are considered and consequently promote an improvement in the ecosystem (Carvajal-Muñoz & Carmona-Garcia, 2012).

This way, the objective was to evaluate the agronomic performance and SPAD index of the garlic crop under the use of organomineral fertilizer.

Materials and Methods

The experiment was carried out at Agrícola Wehrmann, in the municipality of Cristalina-GO during 2017. The area is located at coordinates 16°04'54.7" S, 47°31'26" W and at 1000 m of altitude. Garlic was planted on May 12, 2017 and was used the cultivar Quitéria, from the Nobre group and of long-cycle, characterized by having large bulbils.

The experimental design was a randomized block design (DBC) with five treatments and four replications, totaling 20 experimental plots. Each plot had 12 cm between plants, single rows spaced at 10 cm and double rows at 35 cm.

The chemical and physical properties of the soil prior to the experiment were: pH ($CaCl^2$) 5.6; P (resin), 63.2 mg dm^{-3}, S-SO_4^{2-}: 37.6 mg dm^{-3}, K^+: 245.6 mg dm^{-3}, Ca^{2+}:4.8 cmolc dm^{-3}, Mg^{2+}: 1.5 mmolc dm^{-3}, Al^{3+}: 0.1 mmolc dm^{-3}, B: 1.4 mg dm^{-3}, Zn: 18.6 mg dm^{-3}, Fe: 17.8 mg dm^{-3}, Mn: 23.7 mg dm^{-3}, Cu: 3.9 mg dm^{-3}, SB: 28 mmolc dm^{-3}, soil base saturation: 67.6%.

During pre-planting, fertilization was performed using simple superphosphate with 18% P_2O_5, at a dose of 1 t ha^{-1} in total area and at the time of planting, different rates of organomineral fertilizer Vigor Fert 02-20-05 were used. The control consisted of the producer's standard mineral fertilizer, with fertilizer 03-35-06.

Calculations were carried out for organomineral fertilizers to approximate the content of nutrients contained in them to that of the control. Thus, treatment 2 had the same concentration of the control and the others had decreasing rates of nutrients: Control treatment - 100% Mineral (2200 kg ha^{-1}), 100% Organomineral (3680 kg ha^{-1}), 80% Organomineral (2944 kg ha^{-1}), 60% Organomineral (2208 kg ha^{-1}) and 40% Organomineral (1472 kg ha^{-1}).

The other crop treatments were in accordance with the requirement of the garlic crop, with pesticides applications according to pests and diseases monitoring, using registered products, in the recommended rate.

Fertilization was done manually then it was incorporated by machine and the planting pits were marked. Garlic seed were placed manually and afterwards the pits were closed. Irrigation was performed through a central pivot, from planting, until about 20 days before harvest, to assist the curing process.

At 75, 100 and 115 days after planting (DAP) measurements of the SPAD index were made in order to identify the nutritional condition of the plants in relation to nitrogen. The readings were taken on the central part of the newly expanded and physiologically mature leaf. The evaluation took place in 20 plants per plot, on the central rows.

At 75 DAP, leaves were also collected to analyze the nutritional status of the plants. In each plot were collected the three younger fully developed leaves.

The harvest was carried out on September 27, 2017 (138 days after planting), when 2/3 of the leaves were already dry and yellow, a period in which the bulbs have already reached physiological maturity and have greater accumulation of dry matter, reducing the possibility of losses during post-harvest drying (Souza & Macedo, 2009). It is considered useful only the two central rows of the plots, the other sides were used as borders.

The plants in each plot were manually harvested, identified and sent to a shed where they remained for 30 days for the curing process. Afterwards, the beneficiation process was carried out, which consists of the toilet, eliminating dirt, leaves and roots, leaving only the bulb. The bulbs were classified, according to the transverse diameter adopted by the Mercosur countries, which divides the bulbs into classes 3 to 8, class 3 has the smaller bulbs (between 26 and 35 mm) and class 8, those with larger transverse bulb diameters (between 78 and 85 mm) (Trani et al., 1997).

Based on the classification and weighing of the bulbs obtained, was carried out the counting of marketable and cull garlic bulbs even as productivity estimate, in tons per hectare, the treatments were submmited to the Tukey test with a 5% significance in the SISVAR statistical program (Ferreira, 2014).

Results and Discussion

Regarding the SPAD Index, there was no significant difference between treatments in any of the three evaluations- 75; 100 and 115 days after planting

(DAP), as shown in table 1.

Table 1. SPAD index on different days after planting.

Pre-planting simple superphosphate			
Treatment	75 DAP	100 DAP	115 DAP
100% (M)	57.29 a*	64.36 a	63.06 a
100% (OM)	60.17 a	63.54 a	61.73 a
80% (OM)	58.43 a	66.00 a	62.46 a
60% (OM)	57.57 a	65.67 a	62.89 a
40% (OM)	58.47 a	67.80 a	63.96 a
CV (%)	6.87	11.42	6.61

* Means followed by the same letter in the column do not differ statistically from each other, by the Tukey test, at 5% significance, DAP: Days after planting.

Fernandes et al. (2011), in spite of not finding an ideal range of SPAD index for garlic cultivation, noticed values that varied between 58 and 70. Oliveira (2011) observed values between 50 and 70. Thus, it was observed that the data observed in the field showed values within the range expressed in the literature.

Portable leaf chlorophyll meters are usefull to estimate chlorophyll contents in an instantaneous, indirect and nondestructive way, constituting an alternative for the evaluation of N concentration in plants, which directly contributes to the increase of crop yield, since more than 90% of plant biomass derives from the photosynthesis (Makino, 2011; Schlichting et al., 2015). According to Hahn et al. (2020) the evaluation of the N status by a portable chlorophyll meter can be a quick strategy for recommending N fertilization and ensuring high yields in the garlic crop.

The levels of nutrients contained in the leaves of garlic are shown in Table 2. In the literature, an ideal range of macros and micronutrients for the cultivation of garlic is not available. Considering that there are variations between cultivars within the same culture and that the leaf contents guide the decision making regarding a better direction of the nutritional practices, the lack of studies and diffusion of information for garlic stands out.

Table 2. Nutritional status of garlic plants at DAP.

	g.kg^{-1}						mg.kg^{-1}				
Treatment	N	P	K	S	Ca	Mg	Cu	Fe	Mn	Zn	B
100% (M)	49.70	4.70	21.50	9.20	5.00	1.40	1.95	289.92	10.65	35.80	14.19
100% (OM)	42.00	5.10	21.50	10.40	5.00	1.90	4.50	106.98	16.20	37.10	11.44
80% (OM)	39.20	4.60	21.50	9.80	5.00	1.60	10.95	136.68	12.90	36.50	10.19
60% (OM)	37.80	5.20	22.00	10.00	5.00	1.70	11.25	93.78	15.75	33.00	10.86
40% (OM)	39.20	4.00	24.00	8.30	4.00	1.50	11.00	126.78	14.55	33.10	11.61

The reduction to 40% of the producer's rate via OM reduced the productivity of garlic by 17.1%. Rates of 100 to 60% did not differ from 100% (M) (Table 3). Regarding the percentage of marketable bulbs (classes 4 to 8), there was no statistically significant difference between mineral and organomineral fertilizations in different rates, that is, all rates reflected a good performance in the production of marketable garlic bulbs.

As for the percentage of garlic destined for industry, fertilization 80% (OM) showed the best performance, with production 8.4% below 100% (OM). It was observed that it was possible to obtain the same quality of 100% (M) with the use of 60% of the rate used by the producer via OM (Table 3).

The reduction to 40% of the producer's rate promoted an increase of 59.4% to the percentage of garlic destined for industry, compared to 100% (M) (Table 3).

Table 3. Productivity and percentage of marketable and cull garlic bulbs.

Treatment	Productivity (t.ha^{-1})	Marketable 4-8 (%)	Cull (%)
100% (M)	15.05 a	74.75 a	10.47 ab
100% (OM)	15.21 a	64.87 a	14.57 bc
80% (OM)	14.98 a	77.76 a	9.60 a
60% (OM)	13.30 ab	78.72 a	11.34 ab
40% (OM)	12.48 b	75.97 a	16.69 c
CV (%)	7.80	3.99	15.84
Mean	14.21	74.42	12.53

Means followed by the same letter in the column do not differ statistically from each other, by the Tukey test, at 5% significance.

Dallamaria et al. (1995) studied the use of OM fertilizer rates compared to mineral and organic fertilizer in the cultivation of garlic, cultivar Quitéria, in the region of São Cristóvão do Sul-SC. The results showed that there was no statistically significant difference between treatments in terms of productivity. Biasi (1995), evaluating the same treatments in the region of Caçador-SC, also did not obtain results with statistically significant difference, however they observed a tendency that smaller rates result in lower productions, which was observed in the results obtained in the present work.

There is a variation between the researches, which are related to climatic conditions, soil type, interactions and dynamics between soil components over the years. In addition, there is a construction of favorable soil characteristics in the long term due to the addition of organic material. The answers also relate to the consonance with the source material and content of the components that form the different OM classes available on the market.

In a study with organic sources via leaf Balmori et al. (2019) observed a favorable response in the productivity and quality of garlic bulbs. The authors highlighted the importance of using organic fractions to make cultivation more sustainable, to minimize the excessive load of minerals in the agro-ecosystem, which generates positive impacts also in economic terms, since mineral fertilizers in general are imported and of high cost (García et al., 2014; Pupo et al., 2016).

Mota et al. (2019) associated the positive OM response with a naturally fertile soil increases and the efficiency of the nutrients available in the system soil–plant, promoting a higher development of the plants treated with organomineral fertilizer. The increase in bulb diameter due to the supply of organic fractions, important commercial and economic implications may occur.

Oliveira et al. (2017) also found positive results with OM fertilizers, even with rate reductions. The authors emphasized the benefits of OM reducing the amount of organic wastes placed incorrectly on the environment, which could pollute water, soil and air (Zandonadi, 2014).

It is worth noting that the acquisition of OM material processed into granules or pellets available on the market has undergone due care in terms of microbiology and the appropriate degree of composting and processing of waste, which differs from non-certified organic sources, which may, eventually, transport agents for harmful microorganisms, seeds of weed plants and possible heavy metals from the decomposition of their constituents, such as garbage, sewage and even poorly tanned manure.

Conclusions

The use of organomineral fertilizer in the rate of 80% offers the same performance in productivity compared to the 100% mineral, in addition to providing a higher quality in national garlic, as it offers a lower percentage of cull garlic bulbs, adding value in the national garlic chain.

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