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Production of Chives Using Organic Fertilizers before Planting and in Top Dressing

Marcelo Munhoz Venâncio de Oliveira[1]
https://orcid.org/0000-0002-0701-9623

Thatiane Nepomuceno Alves[2]*
https://orcid.org/0000-0002-9077-9104

Antonio Ismael Inácio Cardoso[2]
https://orcid.org/0000-0003-3251-9491

Débora Cristina Mastroleo Luís[2]
https://orcid.org/0000-0002-1274-6219

Joseantonio Ribeiro de Carvalho[2]
https://orcid.org/0000-0002-3879-4585

[1]Instituto Agronômico (IAC); Departamento de Agricultura Tropical e Subtropical, Campinas, São Paulo, Brasil; [2]Universidade Estadual Paulista (UNESP), Departamento Produção vegetal/ horticultura, Botucatu, São Paulo, Brasil.

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*Correspondence: thatinepomuceno@hotmail.com; Tel.: 14998218363 (T.N.A)

HIGHLIGHTS

- For production, the fertilizer and the time of application make no difference.
- Recommended to use the hoof and horn powder 100% in top dressing.
- Redution the need for manpower, with just one application moment.

Abstract: Chives are one of the most popular spice plants in world cuisine. It is usually produced by small producers, often in an organic farming system. However, research with chives in this production system is lacking. The purpose of this study was to evaluate the production of chives with the use of organic fertilizers before planting and in top dressing. Seven treatments were evaluated, resulting from the factorial 2x3+1, with two organic fertilizers (castor bean cake and hoof and horn powder) x 3 application modes (100% before planting; 100% in top dressing; 50% before planting and 50% in top dressing) + 1 control (without these organic fertilizers). The experimental design was in randomized blocks, with five replications and plots of 1 m^2. The relative index of chlorophyll ("Spad" index), height, number of leaves, fresh and dry weight of the plants were evaluated. All treatments of the factorial were better than the control, showing that these organic fertilizers improve production in chives. It is recommended to use the hoof and horn powder in installments (50% before planting and 50% in top dressing) or 100% in top dressing, the latter option being more interesting for reducing the need for labor, with just one application moment.

Keywords: *Allium fistulosum*; castor bean cake; hoof and horn powder, nitrogen; organic fertilization.

INTRODUCTION

Chive is a vegetable of considerable value and importance in several regions of Brazil. It has great social importance, because it is cultivated by family farmers, and some of these producing in the organic farming system. However, researches with organic fertilizers in chives are scarce [1]. Organic fertilization, in addition to providing nutrients, improves the soil physical and biological characteristics, and, in tropical regions, organic fertilization becomes more necessary, since the degradation of organic matter is faster [2].

With organic fertilization it is possible to provide all the essential nutrients to the plants, mainly nitrogen (N) and potassium (K). Nitrogen is one of the most absorbed and accumulated by plants and it is recommended to supply it in installments, part before planting and part in top dressing, as it is an easily leachable element, especially in periods of high rainfall and when it is used highly soluble products in conventional cultivation. On the other hand, organic fertilizers provide to the plants nutrients more slowly when compared to inorganic ones, and the rate of release depends on several factors, such as the climatic conditions, microorganisms in soil and source of organic material applied [3].

Interest in organic fertilizers and research demonstrating gains in productivity and better soil characteristics with their use has increased in recent years [4, 5, 6, 7, 8]. However, most of this research has been done with fertilizer applied before planting, and researches about organic fertilizers in top dressing are scarce, but most of them has shown the importance of organic top dressing fertilization [8, 9].

The lack of research about the application of organic fertilization in top dressing in the organic system may be limiting the productivity of vegetables, especially when the soil is poor in nutrients and organic matter. The supply of fertilizers at the right time is important to increase productivity and reduce nutrient losses. Due to the different requirements of nutrients amounts during the growth phases of plants and due to the rapid loss of nitrogen, mainly by leaching, it is important to split its application, to obtain greater production, using less fertilizer, making it possible to reduce costs [10, 11].

As for most species, in chive there are no top-dressing organic fertilization recommendations, only inorganic ones. Among the options of organic fertilizers used by vegetable producers in top dressing application are castor bean cake and hoof and horn powder [12, 13, 11, 3, 8]

Castor bean cake is widely used as a source of nitrogen, which is a nutrient that plants need in large quantities [11, 9]. Organic residues from the processing and slaughter of cattle, sold in the form of hoof and horn powder is also an alternative source of nitrogen. Hoof and horn powder, although less known, has an affordable price, arousing the interest of producers, as it is a cheap source of organic nitrogen [8].

Although castor bean cake and hoof and horn powder are already used by some organic producers, there is a lack of research about these fertilizers. Perhaps because they release nutrients more slowly than inorganic nitrogenous fertilizers, it may not be necessary to divide them in installments, with a reduction in labor costs. From this hypothesis, the objective of this work was to evaluate the production of chives with the use of organic fertilizers before planting and in top dressing.

MATERIAL AND METHODS

The experiment was conducted at the São Manuel Experimental Farm, belonging to the School of Agriculture (FCA) of the Sao Paulo State University (UNESP), Brazil (22°46'S, 48°34'W and altitude of 740 m). The climate of the region, according to Köppen's classification, is mesothermal of the Cwa type, humid subtropical, with a rainy summer and a dry winter. The average monthly rainfall during the experiment was 113.4 mm, while the average maximum temperature was 25.8°C and the minimum temperature was 13.3°C.

The soil of the experimental area was classified as typic distrophic red latosol, sandy texture. The main chemical characteristics of the soil (0-20 cm) were determined by collecting a sample in the area before the implementation of the experiment. The results found presented the following values: pH ($CaCl_2$) = 5.4; organic matter = 38 g dm^{-3}; P= 17 mg dm^{-3}; H+Al= 23 $mmol_c$ dm^{-3}; K= 5.0 $mmol_c$ dm^{-3}; Ca= 50 $mmol_c$ dm^{-3}, Mg= 23 $mmol_c$ dm^{-3}; sum of bases (SB) = 78 $mmol_c$ dm^{-3}, CEC= 101 $mmol_c$ dm^{-3} and base saturation (V%)= 77%.

Seven treatments were evaluated, resulting from the factorial 2x3+1: two organic fertilizers (castor bean cake and hoof and horn powder) x 3 application modes (100% before planting; 100% in top dressing; 50% before planting and 50% in top dressing) + 1 control (without these organic fertilizers, only with the initial fertilization). The experimental design was randomized blocks, with five replications. The amount of each fertilizer was calculated to provide the same total dose of N (90 kg ha^{-1}), based on the recommendation of Raij and coauthors [14] for the state of Sao Paulo, Brazil. Fertilization was carried out before planting with organic compost (16 t ha^{-1}) in the total area, including the control treatment, which corresponds to 112 kg ha^{-1} of N, in addition to the 90 kg ha^{-1} applied with castor bean cake or hoof and horn powder, according to the

treatment. The organic compost used contained, in % of wet matter, 0.7% of N, 1.70% of P_2O_5, 1.78% of K_2O, 1.3% of Ca, 0.8% of Mg and 0.7 % S and 18.0% humidity.

The results of the chemical analysis of the castor bean cake were: pH= 5.7; CO= 20.5%; organic matter = 35.3%; N total= 4.80%; P_2O_5 = 1.87%; K_2O= 1.22 %; Ca= 2.59%; Mg= 0.71%; S= 0.22%; B= 14.5 $mg.kg^{-1}$; Cu= 330 $mg.kg^{-1}$; Mn= 230 $mg.kg^{-1}$; Zn= 33 $mg.kg^{-1}$; Fe= 4194 $mg.kg^{-1}$; C/N= 4.3. The results of the chemical analysis of the hoof and horn powder fertilizer were: pH= 5.8; CO= 7.3%; organic matter = 12.5%; N total= 14.59%; P_2O_5= 0.08%; K_2O= 0.11%; Ca= 0.25%; Mg= 0.04%; S= 1.33%; B= 5.2 $mg.kg^{-1}$; Cu= 66 $mg.kg^{-1}$; Mn= 30 $mg.kg^{-1}$; Zn= 585 $mg.kg^{-1}$; Fe= 90 $mg.kg^{-1}$; ratio C/N= 0.5.

Seeds of cultivar Ano Todo were sown in polypropylene trays with 200 cells, containing Carolina Soil substrate. The seedlings were transplanted on 06/29/2020, in the longitudinal direction of the bed, in four lines (spaced 20 cm each other), with eight holes (spaced 10 cm) per line in each plot. Only the eight central holes of each plot were harvest and evaluated. Sprinkler irrigation was used, about 3 mm per day, and spontaneous plants were controlled through manual weeding.

The harvest was carried out on August 13, 2020, cutting the aerial part (shoot) of the plants close to the ground. The relative index of chlorophyll (“Spad”), height, number of leaves, fresh and dry weight of the plants were evaluated. The relative chlorophyll index was obtained using the equipment Minolta SPAD-502 (Soil Plant Analysis Development), evaluating three plants per plot, taking three measurements per plant, then calculating the average of the measurements taken. With the aid of a ruler, the height from the soil surface to the tip of the highest leaf of the plant was measured. To determine the fresh matter weight, all the harvested plants were weighed on a scale with a precision of 0.1 g and the production per m^2 was estimated. To obtain the dry matter weight, three plants per plot were placed in an oven with forced air circulation at 65ºC and after three days removed to weigh and estimate the dry weight per m^2.

Data were submitted to analysis of variance and Tukey test ($p<0.05$) was used to compare the averages of treatments. The statistical software Sisvar Ferreira [15]) was used.

RESULTS AND DISCUSSION

For the relative index of chlorophyll (Spad), the control treatment presented lower values than the treatments that received the castor bean cake or hoof and horn powder fertilizers, regardless of the moment of application (Table 1).

The Spad meter provides an instantaneous and non-destructive reading of the leaf, being an alternative to evaluate the nutritional status (nitrogen) of the plant in real time due to the fact that there is a significant correlation between the intensity of the green color with the chlorophyll content and with the N concentration in the leaf [16]. Chlorophyll is the pigment that is involved in photosynthesis and is present in all plants, being one of the factors related to the photosynthetic efficiency of plants and, consequently, to the development and production of plants. Some studies positively correlate chlorophyll with leaf N concentration, since 70% of this nutrient contained in leaves is in chloroplasts participating in the synthesis and structure of chlorophyll molecules [17]. This evaluation method has the potential to identify situations where the additional application of N is not necessary.

Therefore, even without performing the foliar analysis, with the Spad index it is possible to conclude that there was a deficiency of N in the leaves of the control treatment plants that were fertilized only with organic compost before planting, but received a smaller amount of this nutrient in relation to the treatments of the factorial. Similar results were reported by Luís and coauthors [2], in parsley, that is, a lower value of the Spad index in the treatment with a lower amount of organic fertilizers. In addition, professionals in the area of gastronomy and nutrition recommend foods with greener and brighter leaves, that is, higher values of the Spad index represent leaves with more intense green and better acceptance by the consumer.

Table 1. Mean values of the "Spad" index, plant height, fresh and dry matter weight of chive plants, depending on the modes of application of castor bean cake and hoof and horn powder.

Treatments	100% before planting	100% in top dressing	50% before planting and 50% in top dressing
	"Spad" index		
Castor bean cake	49.1 a A	47.0 b A	50.6 b A
hoof and horn powder	47.2 a B	54.5 a A	56.5 a A
Control	45.3*		
CV	6.8 %		
	Number of sheets (units m^{-2})		
Castor bean cake	370 a A	312 a A	335 a A
hoof and horn powder	390 a A	330 a A	330 a A
Control	315		
CV	16.7 %		
	Plant height (cm)		
Castor bean cake	55.6 a A	56.1 a A	57.2 a A
hoof and horn powder	58.6 a A	58.6 a A	56.9 a A
Control	53.1*		
CV	5.3 %		
	Fresh matter weight (kg m^{-2})		
Castor bean cake	4.02 a A	4.21 a A	4.25 a A
hoof and horn powder	4.09 a A	4.20 a A	4.10 a A
Control	3.28*		
CV	10.2%		
	Mass of dry matter (kg m^{-2})		
Castor bean cake	0.36 a A	0.36 a A	0.35 a A
hoof and horn powder	0.35 a A	0.36 a A	0.34 a A
Control	0.31*		
CV	9.8 %		

CV%= coefficient of variation. Means followed by same letter, lower case in colunms and upper case in lines, do not differ by Tukey`s test at 5% of probability. * Average of control differ from the average of factorial treatments

In the comparison between the factorial treatments, a higher value of the Spad index was observed in the plants treated with hoof and horn flour fertilizer in relation to castor bean cake when the application was made in cover, both 100% and 50% (Table 1). For the castor bean cake, there was no difference in the application modes, while for the hoof and horn flour, a higher value was observed when the application was made in coverage, both 100% and 50%, compared to the 100% application. in planting. The evaluation of this index was carried out at the end of the cycle, that is, top dressing probably made the nutrients available, especially N, at a time closer to the evaluation compared to the 100% application before planting. Comparing the fertilizers, according to Almeida and coauthors [18] and Nordi and coauthors [8], hoof and horn flour can be considered one of the most efficient organic fertilizers for releasing nutrients, mainly nitrogen. Also Almeida and coauthors [18] reported that this fertilizer is more efficient in releasing nitrogen in the biofertilizer compared to other organic fertilizers, such as bone meal, blood meal and castor bean cake. Therefore, when hoof and horn flour was used, there must have been a large release of nitrogen at the beginning of the cycle, which may have been lost by leaching (average precipitation greater than 120 mm per month) and may have lacked N closer to the end of the cycle when the Spad index was evaluated.

There was no difference for the number of leaves, not even between the control and the factorial treatments (Table 1). However, the control treatment showed lower values for height, fresh and dry weight of the plants, showing that only the organic compost applied before planting was not enough to obtain the best

results. Probably, there was a lack of nutrients, mainly nitrogen, as observed by the lowest value in the Spad index, and, therefore, although the number of leaves did not differ, the plants grew more and the leaves were thicker and heavier in the cake treatments castor or hoof and horn flour, resulting in an increase in fresh and dry mass in these treatments. Martins and coauthors [19] reported an increase in chive productivity the higher the dose of organic compost, with doses ranging from 0 to 105 t ha^{-1}, that is, doses much higher than those used in this work, which confirms that only 16 t ha^{-1} of compost is really little to meet the needs of chive plants aiming at high productivity.

The fertilizers used, castor oil cake and hoof and horn flour, have been little studied. However, in research already published, a beneficial effect has been observed, with an increase in productivity in different vegetables, such as beetroot [9], zucchini [11], cabbage [12, 13], arugula [20]), jambu [8] and parsley [12].

In the comparison between the fertilizers, no differences were obtained either for height or for fresh and dry matter mass, as well as there was no difference between the times of application of the castor bean pie and hoof and horn flour fertilizers (Table 1). Nordi and coauthors [17] and Luis and coauthors [2] reported that hoof and horn flour was superior to castor bean cake when used as a topping for jambu and parsley, respectively.

Both fertilizers, castor bean cake and hoof and horn powder, are residues that, if not used, can cause environmental contamination or high costs for proper storage. Therefore, research that proves the quality of these products in the production of vegetables not only favors producers by offering new possibilities for organic fertilizers, but also collaborates in the sustainable use of these products.

CONCLUSION

Considering only the production characteristics (height, number of leaves, fresh and dry matter weight) it could be concluded that the fertilizer and the time of application make no difference. However, considering the color, indirectly evaluated by the Spad index, it is recommended to use the hoof and horn powder in installments (50% before planting and 50% in top dressing) or 100% in top dressing, the latter option being more interesting for reducing the need for manpower, with just one application moment.

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REFERENCES

1. Martins BNM, Castro JLM, Candian JS, Jorge LG, Cardoso AII. Chives production according to planting density. Res., Soc. Dev. 2020; 9 (9): e108997085.
2. Luis DCM, Cardoso AII, Alves TN, Oliveira MMV, Pelvine RA. Parsley production using organic fertilizers before planting and in top dressing. Comun. Sci. 2023; 1-19.
3. Monsalve OI, Gutiérrez JS, Cardona WA. [Factors involved in the process of nitrogen mineralization when organic amendments are added to a soil]. Review. Rev. Col. de Ciên. Hort; 2017*;* 11: 200-9.
4. Candian JS, Martins BNM, Cardoso AII. [Doses of organic compost in the early development of cauliflower and chemical characteristics of the soil]. Cultivando o Saber**.** 2015; 8 (3), 257-66.
5. Corrêa CV, de Sousa Gouveia AM, Martins BNM, Tavares AEB, Lanna NDBL, Cardoso AII, et al. Response of broccoli to sulphur application at topdressing in the presence or absence of organic compost at planting. Afr. J. Agric. Res. 2016; 11 (35), 3287-92.
6. Lanna NB, Silva PNL, Colombari LF, Freitas-Nakada PG, Cardoso AII. Doses of organic compost on yield and accumulation of macronutrients on endive. Hortic. Bras. 2017; 35: 621-7.
7. Magro FO, Silva, EG, Takata, WHS, Cardoso, AII, Fernandes, DM, Evangelista. Organic compost and potassium top dressing fertilization on production and quality of beetroot. Aust.J.Crop Sci. 2015 9 (10): 962-7.
8. Nordi NT, Cardoso AII, Alves TN, Moraes V, Carvalho JR. Organic fertilization in top dressing in jambu production. Comun. Sci. 2022;13,e3827.
9. Silva PNL, Lanna NBL, Cardoso AII. 2016. [Beet production depending on rates of castor bean cake as top dressing]. Hortic Bras. 2016*;* 34: 416-21.
10. Colombari LF, Lanna NB, Guimarães LR, Cardoso AII. [Production and quality of carrot in function of split application of nitrogen doses in top dressing]. Hortic Bras*.* 2018; 36: 306-12.
11. Lanna NBL, Bardiviesso EM, Tavares AEB, Silva PNL, Nakada-Freitas PG, Noda SBH, et al. Castor bean cake in top-dressing application as a source of nitrogen on the production and quality of zucchini organic seeds. Biosci J. 2020; 36: 130-42.
12. Cardoso AII, Oliveira JB, Lanna NBL, Candian JS, Castro JLM. Sources and splitting of the organic fertilization in top dressing in the production of cabbage. Hortic Bras. 2020; 38: 230-4.
13. Hounmenou GVL, Candian JS, Inowe MA, Colombari LF, Cardoso AII, Magro FO. Cabbage production in function of castor bean cake doses in top dressing. Comun. Sci. 2021; 12: e3453-e3453.

14. Raij B V, Cantarella H, Quaggio AJ, Furlani AMC. [Fertilization and liming recommendations for the State of São Paulo]. 2.ed. Campinas: IAC, 1997. p.171. (IAC. Boletim Técnico, 100).
15. Ferreira DF. SISVAR: A computer analysis system to fixed effects split plot type designs. Res (BJB). 2019;37:529-35.
16. Porto JS, Amorim YF, Rebouças TNH, Lemos OL, Luz JMQ, Costa Q. Tomato plant growth and SPAD index in different nitrogen sources and levels. Scientia Plena. 2014;10:110203.
17. Ferreira MMM, Ferreira GB, Fontes PCR, Dantas JP. [SPAD index and chlorophyll content in tomato leaves as a function of nitrogen doses and organic fertilization, at two different growing seasons]. Rev. Ceres. 2006; 53: 83-92.
18. Almeida LG, Candian JS, Cardoso AII, Grassi Filho H. Nitrogen, phosphorus and potassium content of six biofertilizers used for fertigation in organic production system. Comun. Sci. 2021; 12:e3275-e3275.
19. Martins BNM, Candian JS, Colombari LF, Rodrigues MM, Cardoso AII. Doses of organic compost in top dressing in the production of chives. Res., Soc. Dev.2021;10 (3), e57910313704.
20. Cruz LKA, Ruffino GM, Pelvine RA, Cardoso AII. [Sources of organic fertilizers on arugula production]. Res., Soc. Dev. 2021;16:123-31.