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Parsley production using organic fertilizers before planting and in top dressing

Débora Cristina Mastroleo Luís[1]*, Antonio Ismael Inácio Cardoso[1], Thatiane Nepomuceno Alves[1], Raíra Andrade Pelvine[1], Marcelo Munhoz Venâncio de Oliveira[2]

[1]São Paulo State University, Botucatu, Brazil
[2]Campinas Agronomic Institute, Campinas, Brazil
*Corresponding author, e-mail: debora.mastroleo@unesp.br

Abstract

The objective of this research was to evaluate the effect of two organic fertilizers used before planting and in top dressing in the production of parsley. Seven treatments were evaluated, resulted from the factorial 2 x 3 + 1: two organic fertilizers (castor bean cake, and hoof and horn powder) x 3 modes of application (100% before planting; 100% in top dressing; 50% before planting and 50% in top dressing) + 1 control. The experimental design was in randomized blocks, with five replications and plots of 1 m^2. Two harvests were done and in both the following characteristics were evaluated: the relative chlorophyll index (“Spad''), plant height, fresh (FW) and dry (DW) matter weight of shoot and macronutrients accumulation. There was no significant difference for the ''Spad” index in both harvests. For the other characteristics, the control was inferior to the other treatments. In the comparison among application modes, the treatment with castor bean cake, 100% before planting, was inferior to the other applications modes of this fertilizer for FW and DW. For hoof and horn powder, the 100% in top dressing application mode was superior to other applications. In the comparison between fertilizers, the hoof and horn powder was superior to castor bean cake in both harvests when application was done 100% before planting. The descending order of macronutrients accumulation was: K > N > Ca > P > Mg. Therefore, it is recommended to apply hoof and horn powder, 100% in top dressing application

Keywords: castor bean cake, hoof and horn powder, nitrogen, organic fertilization, *Petroselinum crispum*

Introduction

Parsley (*Petroselinum crispum*) is a leafy vegetable whose aromatic potential is well known. It has stood out as an important spice vegetable, for its wide application in the gastronomic and herbal market and for its social importance, because it is produced mainly by small producers (Heredia Z et al., 2003), often in organic system.

Due to the high extraction and export of nutrients by vegetable plants, it is necessary to replace them via organic or inorganic fertilization. Organic fertilization can provide destination for urban, industrial waste and the large volume of animal excrement produced on various properties, transforming them into fertilizers.

Aiming to achieve high productivity of vegetables and sustainability in crops, the interest of producers in organic fertilization is growing (Magro et al., 2015). With the use of organic fertilizers, the availability of nutrients occurs throughout the cycle, not being readily leachable; improves the structure of the soil and, consequently, protects it from erosion; provides macro and micronutrients and improves physical, chemical and physicochemical soil conditions (Monsalve et al., 2017).

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 (Colombari et al., 2018; Lanna et al., 2020).

Among the options of organic fertilizers used by vegetable producers in top dressing application are castor bean cake and hoof and horn powder (Silva et al., 2016; Cardoso et al., 2020; Lanna et al., 2020; Almeida et al., 2021; Hounmenou et al., 2021). Castor bean cake is an organic fertilizer, widely used as a source of nitrogen, which is a nutrient that plants need in large quantities (Silva et al., 2016; Lanna et al., 2020), including parsley

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(Heredia Z et al., 2003). There are also other nutrients in the castor bean cake, such as phosphorus, potassium and micronutrients, but in smaller amounts.

Organic residues from the processing and slaughter of cattle, sold in the form of hoof and horn powder are alternative sources of nitrogen (about 14% N) and phosphorus (about 27% P_2O_5), respectively. 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 (Almeida et al., 2021).

Although these products are used by producers in the organic system, there is little scientific information about them. Therefore, the objective of this research was to evaluate the effect of these organic fertilizers used before planting and in top dressing on the production and extraction of nutrients in parsley.

Material and Methods

The experiment was carried out under field conditions, at São Manuel Experimental Farm, located in the municipality of São Manuel-SP (22°46'28''S, 48°34'37''W, 750 m altitude), at São Paulo State University (UNESP), campus Botucatu-SP. 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 is 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_{resin}= 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.

On 06/19/2020, base fertilization (3.2 kg of organic compost per m²) was carried out before planting in total area. The organic compost used contained, in % of dry 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 17.95% humidity.

Seven treatments were evaluated, resulting from a 2 x 3 + 1 factorial scheme: two organic fertilizers (castor bean cake, and hoof and horn powder) x 3 modes of application (100% before planting; 100% in top dressing; 50% before planting and 50% in top dressing) + 1 control treatment (without these organic fertilizers, only with the base fertilization). A randomized complete block design with five replications was used. The amount of each fertilizer was calculated in order to provide the same total N dose (90 kg ha^{-1}), recommended for the State of São Paulo (Raij et al., 1997), according to the modes of application, in addition to that provided in the total area with the organic compost.

The results of chemical analysis of castor bean cake are: pH= 5.7; humidity=0.0; organic matter=35.3%; total N=4.8%; 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 ratio = 4.3. The results of the chemical analysis of the hoof and horn fertilizer are: pH= 5.87; humidity=7.2%; organic matter= 12.5%; Total N=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}; C/N ratio = 0.5. All values are expressed for dry matter. The chemical analyzes of the soil and organic fertilizers were carried out by the Laboratories of the Department of Soils and Environmental Resources at FCA/UNESP.

The seedlings of cultivar Lisa were produced in trays with 200 cells, with Carolina Soil substrate. The transplant was carried out on 06/29/2020 in beds 25.0 m long, 1.0m wide and 0.2 m high, with a spacing of 25 cm between rows and 10 cm between holes, with 40 holes per plot (four rows with ten holes each). The control of weeds was done manually. It was not necessary to control pests and diseases and a sprinkler irrigation system was used, applying, in the absence of rain, about 4 mm of water per day.

For evaluation, only the plants of the six holes in the center of the plots were used. The first harvest was carried out on 08/13/2020, cutting the aerial part of the plants close to the ground. The plants regrowth and a second harvest were carried out on 10/08/2020. In both harvests, the following characteristics were evaluated: a) relative chlorophyll index ("Spad"): it was evaluated by taking three measurements per plant, and the average was calculated. The Minolta SPAD-502 (Soil Plant Analysis Development) equipment was used; b) plant height: with the aid of a ruler, the height from the soil surface to the tip of the highest leaf of the plants was measured; c) fresh matter weight: all harvested plants were weighed on a Bel Engineering scale with a precision of 0.2 g, and the value per 1 m² was estimated; d) dry matter weight: the plants were placed in a forced air circulation oven at 65°C and after three days removed for weighing. Then, the value per 1 m² was estimated; e) accumulation of macronutrients: to determine the nutrient content (except sulphur), samples were collected from all plots and were sent to the FCA/UNESP plant chemical analysis laboratory to determine the macronutrient content in the plants. The chemical analysis methodology was sulfur digestion to determine nitrogen, and nitric-perchloric digestion for the other macronutrients, according to the methodology described by (Malavolta et al., 1997). The accumulation of nutrients was obtained by the proportionality of the content with the dry weight of the sample.

Analysis of variance was performed and means were compared using the Tukey test (5%). Data were processed by Sisvar software (Ferreira, 2014).

Results and Discussion

For the relative chlorophyll index ("Spad" index), no differences were observed between treatments both in the first (**Table 1**) and in the second (**Table 2**) harvests, regardless of the fertilizer and the mode of application, with averages of 37.20 and 37.18, respectively.

The "Spad" index can be indicative of N deficiency and helps in the management of nitrogen fertilization of some vegetables (Mógor et al., 2013; Nasser et al., 2020). Studies with increasing applications of nitrogen and organic fertilizers in zucchini (Ferreira et al., 2006) and tomatoes (Porto et al., 2011) found increases in chlorophyll contents and "Spad" index values, which was not observed in the present study when comparing the control with the treatments that received castor bean cake or hoof and horn powder. When comparing only the factorial treatments, the absence of difference can be explained by the fact that the same amount of N was applied. In the case of the control, the dose was not zero, it was just lower, as organic compost was applied before planting in all plots. The treatments only reflect the application of the N recommended for the "conventional" system for the State of São Paulo (Raij et al., 1997) in the form of organic fertilizer.

Table 1. Average values of the "Spad" index, plant height, fresh and dry weight of parsley plants, depending on the application modes of castor bean cake and hoof and horn powder in the first harvest (08/13/2020). FCA/UNESP, São Manuel-SP, 2020

Treatments	100% before Planting	100% in top dressing	50% before planting and 50% in top dressing
	"Spad" index		
Castor bean cake	34.20 aA	37.92 aA	39.56 aA
Hoof and horn powder	37.82 aA	37.42 aA	38.56 aA
Control		35.20	
CV%		9.34	
	Plant height (cm)		
Castor bean cake	28.57 aB	33.36 aA	31.40 aAB
Hoof and horn poder	31.79 aA	31.47 aA	29.73 aA
Control		25.26*	
CV%		8.73	
	Fresh matter weight (kg m^{-2})		
Castor bean cake	2.010 bB	2.671 aA	2.592 aA
Hoof and horn powder	2.564 aA	2.651 aA	2.370 aA
Control		1.780*	
CV%		14.60	
	Dry matter weight (kg m^{-2})		
Castor bean cake	0.272 bB	0.319 aA	0.303 aA
Hoof and horn powder	0.302 aA	0.301 aA	0.280 bA
Control		0.24*	
CV%		15.32	

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 organic system, the supply of adequate amounts of N to plants is more difficult than in the conventional system (Castro et al., 2005). The equipment used provides an instantaneous and non-destructive reading to the leaf, being an alternative to evaluate the plant's nitrogen 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 the N concentration in the leaf (Porto et al., 2011, 2014), since 70% of this nutrient contained in the leaves is in chloroplasts, participating in the synthesis and structure of chlorophyll molecules (Ferreira et al., 2006). 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 their growth.

For plant height, it is observed that the control was inferior to the other treatments in both harvests. In the first harvest, the value for the control was 25.26 cm (Table 1) and in the second, 19.47 cm (Table 2), while the factorial treatments had a mean of 31.05 and 25.37 cm, in first (Table 1) and second (Table 2) harvests, respectively. Height is a characteristic widely evaluated in studies in many species, as it can be easily obtained, without the destruction of the plant, presenting direct responses to the application of fertilizers, especially nitrogen (Porto et al., 2014), as observed in the present study.

In the comparison between the application modes, it is observed that with the use of castor bean cake the height of the plants with the 100% application in top dressing (33.36 cm) was higher than the 100% application before planting (28.57 cm) in the first harvest, while for the hoof and horn powder there was no difference between the application modes in this first harvest (Table 1). There were no differences between the fertilizers in the three application methods.

Table 2. Average values of the "Spad" index, plant height, fresh and dry weight of parsley plants, depending on the application modes of castor bean cake and hoof and horn powder in the second harvest (10/08/2020). FCA/UNESP, São Manuel-SP, 2020

Treatments	100% before Planting	100% in top dressing	50% before planting and 50% in top dressing
"Spad" index			
Castor bean cake	38.20 aA	38.86 aA	36.94 aA
Hoof and horn powder	36.04 aA	40.24 aA	36.80 aA
Control		33.20	
CV%		9.73*	
Plant height (cm)			
Castor bean cake	22.60 aA	26.87 aA	25.03 aA
Hoof and horn powder	24.78 aA	28.53 aA	24.41 aA
Control		19.47*	
CV%		13.55	
Fresh matter weight (kg m^{-2})			
Castor bean cake	1.493 bB	2.179 aA	1.820 aAB
Hoof and horn powder	1.998 aA	2.436 aA	2.070 aA
Control		1.110*	
CV%		15.09	
Dry matter weight (kg m^{-2})			
Castor bean cake	0.149 bB	0.218 aA	0.182 aAB
Hoof and horn powder	0.199 aA	0.244 aA	0.207 aA
Control		0.111*	
CV%		15.07	

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 second harvest, no differences were observed for plant height, neither among the fertilizers, nor in the application modes (Table 2), only the control treatment was inferior to the factorial treatments.

The values observed in the first harvest (25.26 to 33.36 cm) are similar to those reported by (Heredia Z et al., 2003) (mean 28.41 cm) with the same cultivar Lisa and higher than those reported by (Nascimento et al., 2017) (16.40 to 19.52 cm) for 'Graúda Portuguesa' parsley produced with different N rates (0 to 160 kg ha^{-1} of N) in the form of urea.

For fresh matter weight, it was also observed that the control treatment presented inferior results than the factorial treatments, in both harvests, with averages of 1.78 kg m^{-2} in the first (Table 1) and 1.11 kg m^{-2} in the second (Table 2) harvest. In the comparison between the application modes, it is observed that for castor bean cake the applications 100% in top dressing (2.671 kg m^{-2}) and the application 50% before planting and 50% in top dressing (2.592 kg m^{-2}) the values were higher than in the application 100% before planting (2.010 kg m^{-2}) in the first harvest (Table 1). In the second harvest, only the 100% top dressing application (2.179 kg m^{-2}) was superior to the 100% application before planting (1.493 kg m^{-2}) (Table 2). On the other hand, for hoof and horn powder, there was no difference between the application methods both in the first (Table 1) and in the second (Table 2) harvests.

In the comparison between the fertilizers, in both harvests, hoof and horn powder resulted in greater fresh matter weight than the treatment with castor bean cake only when 100% was applied before planting, with no difference between the fertilizers in the other two application modes (Tables 1 and 2).

The control treatment presented lower dry matter weight compared to the factorial treatments both in the first (Table 1) and in the second (Table 2) harvest. For castor bean cake in the first harvest (Table 1), the treatment 100% before planting (0.272 kg m^{-2}) was inferior to the application 100% in top dressing and 50% before planting and 50% in top dressing, which presented averages of 0.319 kg m^{-2} and 0.303 kg m^{-2}, respectively. For the second harvest (Table 2), only the treatment with application of castor bean cake 100% in top dressing (0.218 kg m^{-2}) was superior to that with 100% application before planting (0.149 kg m^{-2}). When the hoof and horn powder was used, there was no difference between the application modes, both in the first (Table 1) and in the second (Table 2) harvest.

In the comparison between the fertilizers, the plants in the treatments with hoof and horn powder had higher dry matter weight than those of castor bean cake when applied 100% before planting both in the first (Table 1) and in the second harvest (Table 2).

In the sum of the two harvests, the results were similar to those of each individual harvest, that is, the control treatment resulted in lower fresh and dry matter weight compared to the factorial treatments (**Table 3**), while the hoof and horn powder was superior to castor bean cake only when applied 100% before planting and in the comparison between the application modes, there was difference only for castor bean cake, with lower values with 100% application before planting.

The values obtained for fresh matter weight in the first harvest (1.78 to 2.67 kg m^{-2}) were higher than those reported by (Heredia Z. et al.,2003): 0.58 kg m^{-2}; and by (Nascimento et al., 2017): 0.28 to 0.36 kg m^{-2}.

When castor bean cake or hoof and horn powder were applied, plants with greater heights, fresh and dry matter weight were obtained compared to the control treatment without the use of these fertilizers, only

Table 3. Average values of the total (first plus second harvest) fresh and dry weight of parsley plants, depending on the application modes of castor bean cake and hoof and horn powder. FCA/UNESP, São Manuel-SP, 2020

Treatments	100% before planting	100% in top dressing	50% before planting and 50% in top dressing
	Fresh matter weight (kg m^{-2})		
Castor bean cake	3.504 bB	4.850 aA	4.413 aA
Hoof and horn powder	4.562 aA	5.087 aA	4.450 aA
Control	2.90		
CV%	12.08		
	Dry matter weight (kg m^{-2})		
Castor bean cake	0.421 bB	0.537 Aa	0.484 aAB
Hoof and horn powder	0.503 aA	0.545 Aa	0.489 aA
Control	0.36		
CV%	12.51		

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.

with base fertilization with organic compost. Therefore, it can be concluded that these fertilizers are efficient in increasing the production of parsley in the organic system. (Silva et al., 2016), (Cardoso et al., 2020), (Lanna et al., 2020) and (Cruz et al., 2021) reported increased productivity with the use of castor bean cake in beets, cabbage, zucchini and rocket, respectively. However, (Nascimento et al., 2017) did not observe differences in plant height or in fresh and dry matter weight of 'Graúda Portuguesa' parsley when studying nitrogen doses (0 to 160 kg ha^{-1}, in the form of urea) in top dressing, this is, even at doses higher than those used in this research.

In addition to releasing nutrients, organic fertilizers also improve the physical, biological and chemical structures of the soil, and this, for some species, is closely linked to biomass production, especially in tropical environments, where the degradation of organic matter is more intense and faster (Primavesi, 2016).

Besides the control, the treatment which presented, on average, the worst results were with the application of castor bean cake 100% before planting, resulting in lower values of fresh and dry matter weight in both harvests (Tables 1 and 2). According to (Severino et al., 2004), castor bean cake is one of the organic fertilizers with the fastest nitrogen release. Therefore, when placing 100% before planting, there was probably a large release at the beginning of the cycle and may have resulted in lower availability of this nutrient to plants throughout the cycle.

On the other hand, when 50% or 100% was applied in top dressing, it provided greater nitrogen release in the second half of the cycle, the stage of greatest plant development, resulting in greater accumulation of both fresh and dry matter. In arugula, (Cruz et al., 2021) found no difference with the application of castor bean cake before planting or in top dressing. However, it should be noted that the arugula cycle was approximately half of that observed in the first harvest of parsley in this research, that is, probably the castor bean cake applied by these authors before planting must have provided nutrient release throughout the entire period of arugula cycle.

When 100% was applied before planting, the treatment with hoof and horn powder was superior to that with castor bean cake, but it did not differ in the other modes of application. (Nordi, 2021) reported that the hoof and horn powder applied in top dressing resulted in higher production of fresh and dry matter in "jambu" plants compared to other organic fertilizers tested (castor bean cake, Bokashi, Ferticel® and Provaso®). According to (Cavalaro Junior et al., 2009), hoof and horn powder can be considered as one of the most efficient organic fertilizers for the release of nutrients, especially nitrogen. (Almeida et al., 2021) reported that this fertilizer is more efficient in releasing nitrogen in the biofertilizer compared to other organic fertilizers, such as bone flour, blood flour and castor bean cake.

It is observed that the control treatment showed lower accumulation of all macronutrients (in the sum of the two harvests) compared to the factorial treatments, with means (g m^{-2}) of 7.54; 1.10; 17.28; 2.30 and 0.82 for N, P, K, Ca and Mg, respectively (**Table 4**).

In the comparison between the fertilizers, a greater accumulation of N, P and K was obtained with the use of hoof and horn powder compared to castor bean cake only when these fertilizers were applied 100% before planting, while in the other two application modes (100% in top dressing and 50% before planting + 50% in top dressing) there was no difference for accumulation between the fertilizers for these three nutrients (Table 4). This result follows what was observed for the dry matter weight, in which only in this mode of application (100% before planting) there was difference between the fertilizers in the two harvests, that is, with higher values of dry matter weight with the hoof and horn powder compared to castor bean cake, both in the first (Table 1) and in the second (Table 2) harvests and in the sum of these (Table 3). Considering that the accumulation estimation is made from the content obtained in the analysis of the leaves multiplied by the dry matter weight of the sample, this is an expected result (Cardoso et al., 2017).

Table 4. Macronutrients accumulation in parsley plants depending on the application modes of castor bean cake and hoof and horn powder. FCA/UNESP, São Manuel-SP, 2020

Treatments	100% before planting	100% in top dressing	50% before planting and 50% in top dressing
Nitrogen ($g.m^{-2}$)			
Castor bean cake	8.78 bA	11.14 aA	11.57 aA
Hoof and horn poder	12.72 aA	13.38 aA	12.64 aA
Control		7.54*	
CV%		18.19	
Phosphorus ($g.m^{-2}$)			
Castor bean cake	1.33 bA	1.71 aA	1.82 aA
Hoof and horn powder	1.92 aA	2.01 aA	1.77 aA
Control		1.10**	
CV%		17.10	
Potassium ($g.m^{-2}$)			
Castor bean cake	19.78 bA	24.89 aA	26.55 aA
Hoof and horn powder	27.22 aA	29.59 aA	25.56 aA
Control		17.28*	
CV%		15.08	
Calcium ($g.m^{-2}$)			
Castor bean cake	3.43 aA	3.35 aA	2.74 aA
Hoof and horn powder	3.50 aA	3.90 aA	3.74 aA
Control		2.30*	
CV%		13.35	
Magnesium ($g.m^{-2}$)			
Castor bean cake	1.18 aA	1.14 aA	1.09 aA
Hoof and horn powder	1.18 aA	1.24 aA	1.14 aA
Control		0.82*	
CV%		13.19	

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.

Also, for these three nutrients (N, P and K) it is observed that for castor bean cake the accumulation values were lower when 100% was applied before planting compared to the other two modes (100% in top dressing and 50% before planting + 50% in top dressing) (Table 4), that is, also following the accumulation of total dry matter weight (Table 3) without, however, differing statistically.

For Ca and Mg accumulation there was no difference between the fertilizers or between the modes of application, only the mean of the control treatment was lower than the others (Table 4).

The descending order of macronutrient accumulations in the leaves of the parsley plants was K > N > Ca > P > Mg (Table 4). No researches were found describing the accumulation of nutrients in parsley, which prevents comparison with other authors. However, it is observed that K is the most accumulated nutrient, followed by N, what is also observed in different leaf vegetables, such as endive (Lanna et al., 2017), kale (Nasser et al., 2020) and cabbage (Corrêa et al., 2013), as well as in roots such as carrots (Colombari et al., 2018) and beets (Cardoso et al., 2017), and in fruit vegetables such as zucchini (Araújo et al., 2015) and watermelon (Grangeiro & Cecílio Filho, 2005).

In general, the descending order for macronutrients requirements of vegetable plants is K > N > Ca > Mg > P=S (Faquin & Andrade, 2004), that is, an order similar to that observed in parsley, except for the greater accumulation of P in this research in relation to Mg. Differences in the ordering of macronutrient accumulation in different studies can be attributed to the specificities of each species, the environmental conditions in which the plants were grown, soil fertility and plant nutrition, in addition to growing season (Araújo et al., 2015). However, the results observed in this research are not so out of line, showing that K and N really are the nutrients most removed by horticultural plants, including parsley.

Conclusions

Both fertilizers resulted in higher parsley productivity and it is recommended their utilization by organic producers. However, the best treatment was with the application of hoof and horn powder with 100% in top dressing.

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References

Almeida, L.G; Candian. J.S., Cardoso, A.I.I., Grassi Filho, H. 2021. Nitrogen, phosphorus and potassium content of six biofertilizers used for fertigation in organic production system. *Comunicata Scientiae* 12: e3275.

Cardoso, A.i.I., Magro, F.O., Oliveira Júnior, M.X., Abrahão, C., Tavares, A.E.B., Fernandes, D.M. 2017. Accumulation of macronutrients in beetroot plant. *Horticultura Brasileira* 35: 328-334.

Cardoso, A.I.I., Oliveira, J.B., Candian, J.S., Lanna, N.B.L., Castro, J.L.M. 2020. Sources and splitting of the organic fertilization in top dressing in the production of cabbage. *Horticultura Brasileira* 38: 230-234.

Castro, M.C., Almeida, D.L., Ribeiro, R.L.D., Carvalho, J.F. 2005. No-tillage, green manure and supplementation with poltry manure on organic eggplant production. *Pesquisa Agropecuária Brasileira* 40: 495-502.

Colombari, L.F., Lanna, N.B.L., Guimarães, L.R.P., Cardoso, A.I.I. 2018. Production and quality of carrot in function of split application of nitrogen doses in top dressing. *Horticultura Brasileira* 36: 306-312.

Corrêa, C.V., Cardoso, A.I.I., Claudio, M.T.R. 2013. Yield of cabbage depending on rates and sources of potassium in top dressing. *Semina: Ciências Agrárias* 34: 2129-2138.

Cruz, L.K.A., Ruffino, G.M., Pelvine, R.A., Cardoso, A.I.I. 2021. Sources of organic fertilizers on arugula production. *Revista Brasileira de Agroecologia* 16: 123-131.

Faquin, V., Andrade, A.T. 2004. *Nutrição mineral e diagnose do estado nutricional de hortaliças*. UFLA/ FAEPE, Lavras, Brasil. 88 p.

Ferreira, M.M.M., Ferreira, G.B., Fontes, P.C.R., Dantas, J.P. 2006. Índice SPAD e teor de clorofila no limbo foliar do tomateiro em função de doses de nitrogênio e da adubação orgânica, em duas épocas de cultivo. *Revista Ceres* 53: 83-92.

Ferreira, D.F. 2014. SISVAR: A computer analysis system to fixed effects split plot type designs. *Revista Brasileira de Biometria* 37: 529-535.

Grangeiro, L.C., Cecílio Filho, A.B. 2005. Acúmulo e exportação de macronutrientes em melancia sem sementes. *Horticultura Brasileira* 23: 763-767.

Heredia Z, N.A., Vieira, M.C., Weismann, M., Lourenção, A.L.F. 2003. Produção e renda bruta de cebolinha e de salsa em cultivo solteiro e consorciado. *Horticultura Brasileira* 21: 574-577.

Hounmenou, G.V.L., Candian, J.S., Inowe, M.A., Colombari, L.F., Cardoso, A.I.I., Magro, F.O. 2021. Cabbage production in function of castor bean cake doses in top dressing. *Comunicata Scientiae* 12: e3453.

Lanna, N.B.L., Bardiviesso, E.M., Tavares, A.E.B., Silva, P.N.L., Nakada-Freitas, P.G., Noda. S.B.H., Cardoso, A.I.I. 2020. Castor bean cake in top-dressing application as a source of nitrogen on the production and quality of zucchini organic seeds. *Bioscience Journal* 36: 130-142.

Lanna, N.B.L., Silva, P.N.L., Colombari, L.F., Nakada-Freitas, P.G., Cardoso, A.I.I. 2017. Doses of organic compost on yield and accumulation of macronutrients on endive. *Horticultura Brasileira* 35: 621-627.

Magro, F.O., Silva, E.G., Takata, W.H.S., Cardoso, A.I.I., Fernandes, D.M., Evangelista, R.M. 2015. Organic compost and potassium top dressing fertilization on production and quality of beetroot. *Australian Journal of Crop Science* 9: 962-967.

Malavolta, E., Vitti, G.C., Oliveira, S.A. 1997. *Avaliação do estado nutricional das plantas: princípios e aplicações*. Potafós, Piracicaba, Brasil. 319 p.

Monsalve, O.I., Gutiérrez, J.S., Cardona, W.A. 2017. Factores que intervienen em el processo de mineralización de nitrógeno cuando son aplicadas en meiendas orgânicas al suelo. *Revista Colombiana de Ciências Horticolas* 11: 200-209.

Mógor, Á.F., Barbizan, T., Pauletti, V., Oliveira, J., Bettoni, M.M. 2013. Teores de clorofila em cultivares de tomateiro submetidas a aplicações foliares de magnésio. *Pesquisa Agropecuária Tropical* 43: 10-15.

Nascimento, M.V., Silva Junior, R.L., Fernandes, L.R., Xavier, R.C., Benett, K.S.S., Seleguini, A., Benett, C.G.S. 2017. Manejo da adubação nitrogenada nas culturas de alface, repolho e salsa. *Revista de Agricultura Neotropical* 4: 65-71.

Nasser, M.D., Cardoso, A.I.I., Corrêa, C.V. 2020. Sulfur rates, organic compost and gypsum in macronutrients contents of collard greens leaves. *Comunicata Scientiae* 11: e3352.

Nordi, N.T. 2021. *Adubação orgânica na produção e acúmulo de nutrientes em plantas de jambu*. 67f. (Dissertação de Mestrado). Universidade Estadual Paulista, Faculdade de Ciências Agronômicas, Botucatu, Brasil.

Porto, J.S., Amorim, Y.F., Rebouças, T.N.H., Lemos, O.L., Luz, J.M.Q., Costa, Q. 2014. Tomato plant growth and SPAD index in different nitrogen sources and levels. *Scientia Plena* 10: 110203.

Porto, M.L., Puiatti, M., Fontes, P.C.R., Cecon, P.R., Alves, J.C., Arruda, J.A. 2011. SPAD index for nitrogen status diagnosis of zucchini plants. *Horticultura Brasileira* 29: 311-315.

Primavesi, A. 2016. *Manual do solo vivo*: solo sadio, planta sadia, ser humano sadio. Expressão Popular, São Paulo, Brasil. 205 p.

Raij, B.V., Cantarella, H., Quaggio, J.A., Furlani, A.M.C. 1997. *Recomendações de adubação e calagem para o Estado de São Paulo*. Instituto Agronômico & Fundação IAC, Campinas, Brasil. 175 p.

Severino, L.S., Costa, F.B., Beltrão, N.E.M., Lucena, A.M.A., Guimarães, M.M.B. 2004. Mineralização da torta de mamona, esterco bovino e bagaço de cana estimada pela respiração microbiana. *Revista de Biologia e Ciências da Terra* 5: 1-6.

Silva, P.N.L., Lanna, N.B.L., Cardoso, A.I.I. 2016. Beet production depending on rates of castor bean cake as top dressing. *Horticultura Brasileira* 34: 416-421.

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