Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 8, Issue, 09, pp.38600-38606, September, 2016

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

ACCUMULATION OF MACRONUTRIENTS IN AGATA POTATO CULTIVAR UNDER ORGANO-MINERAL FERTILIZER IN WINTER CROP

***Cardoso, A. F., L. da Almeida, S., Lana, R. M. Q. and Luz, J. M. Q.**

Institute of Agrarian Science, Uberlândia, Brazil, Uberlândia Federal University, Faculty of Agronomy

ARTICLE INFO

Article History:
Received 22nd June, 2016
Received in revised form
15th July, 2016
Accepted 27th August, 2016
Published online 30th September, 2016

Key words:

Efficiency of organic-fertilizer,
Export of nutrients,
Absorption of nutrients.

ABSTRACT

The effect of organo-mineral fertilizers on potato plants is still poorly understood. Therefore, the objective of this study was to evaluate the extraction and uptake of macronutrients by potato plants. The experiment was conducted in the municipality of Cristalina (GO), Brazil, with Agatapotato cultivar during the winter crop. The experimental design was a randomized block with 6rates and 4 repetitions. The rates of organo-mineral fertilizer were based on recommendations for a mineral fertilizer, corresponding to 40, 60, 80, 100 and 120% of a mineral fertilizer. The mean accumulation of nutrients in potato plants was higher for the organo-mineral treatments relative to the conventional mineral fertilizer. Tuber yields in the organo-mineral treatments were identical to the treatment with a mineral fertilizer, including the treatment corresponding to 40% of a mineral fertilizer, which demonstrates the efficiency of organo-mineral fertilizers. The average translocation of macronutrients in treatments with organo-mineral fertilizers was 14% N, 73% P, 45% K, 13% Ca, 83% Mg and 24% S accumulated during the potato growth cycle.

Citation: Cardoso, A. F., L.da Almeida, S., Lana, R.M.Q. and Luz, J.M.Q., 2016. "Accumulation of macronutrients in Agata potato cultivar under organo-mineral fertilizer in winter crop" *International Journal of Current Research*, 8, (09), 38600-38606.

INTRODUCTION

Modern agriculture seeks to maximize the interaction between water, light, CO_2, temperature, nutrients and genotype - factors which influence growth, development and behavior of plants. Among them, fertilization is crucial for most Brazilian soils, which naturally express low fertility (Fontes and Pereira, 2003). Soil correction and fertilization are essential to ensure crop yields which are economically viable for the producer. In this context, organo-mineral fertilizers prove to be more efficient than conventional fertilization materials (Luz *et al.*, 2010).It is because humic substances in the organic matter:(i) enhance and stimulate microbial flora surrounding the root system, (ii) facilitate the release of nutrients, and (iii) increase water retention, aeration, nutrient retention, soil aggregation, and the formation of natural chelates, which directly influence plant nutrition (Souza and Resende, 2003). According to Bertsch (2003), the uptake of nutrients by crops depends on external factors (the environment)and internal factors (genetic potential and plant age). For that reason, an accurate fertilization program for each cultivar, which optimizes the yield of tubers and prevents over-fertilization, predicates on studies of uptake and export of nutrients (ZOBIOLE *et al.*, 2010). In the literature there is dada regarding nutrient uptake by the potato (Macedo *et al.*, 1977; Paula *et al.*, 1986; Yorinori, 2003; Fernandes *et al.*, 2011; Soratto, *et al.*, 2011).However, in recent years new cultivars with increased yield potentialhave been introduced (Faostat, 2016). Therefore, the nutritional requirements of these new cultivars must be attended. According to Faostat, (2016), potato yield levels in Brazil have nearly doubled in recent years, from 10-15 t ha^{-1} in the 1980's to 25-30 t ha^{-1}(in some cases even above 40 t ha^{-1}) currently. In Brazil the potato can be produced throughout the year; however, the winter crop requires irrigation, which helps maintain high average yields (Miranda Filho *et al.* 2003).The Brazilian cerrado soils can easily deliver high tuber yields. Nevertheless, they require substantial correction and fertilization, and are characterized by high fixation of phosphorus (P), magnesium (Mg) and micronutrients (Arimura *et al.*, 2007). In addition, the impact of organo-mineral fertilization on potato plants is still unknown. Therefore, the aim of this study was to evaluate the uptake of macronutrients by potato cultivar Agatain winter crop.

****Corresponding author: Cardoso, A. F.***
Institute of Agrarian Science, Uberlândia, Brazil, Uberlândia Federal University, Faculty of Agronomy.

MATERIALS AND METHODOS

The experiment was conducted in the municipality of Cristalina (GO) with Agata potato cultivar. The municipality is located at an altitude 1189m, with an average rainfall 1426.3mm and average temperature 20.4°C. Field trials were carried out on an area granted by the Agrícola Wehrmann® company during the winter season from May 26, 2012 to August 29, 2012. The soil was classified as Red Latosol with clayey texture (Ferreira, 2010). Soil chemical analysis were carried out on soil samples extracted at 0-20 cm (Donagena *et al.*, 2011) showing the following characteristics: P = 50 mg dm^{-3}; K= 161 mg dm^{-3}; pH = 6,4; Ca^{+2} = 5,4 $cmol_c$ dm^{-3}; Mg^{+2} = 1,0 cmolc dm^{-3}; Al = 0,0 cmolc dm^{-3}; H+Al= 2,0 $cmol_c dm^{-3}$; OM=3,6 g dm-^{3}; V=77%; and T=8,8 $cmol_c$ dm^{-3}. The experimental design was randomized blocks with 6rates and 4 repetitions (Table 1).

Table 1. Description of treatments in the experiment

Treatment	Corresponding percentage of mineral fertilizer	Rate kg ha^{-1}
1	----	2.800
2	40 %	1.629,10
3	60 %	2.443,60
4	80 %	3.258,20
5	100 %	4.072,70
6	120 %	4.887,30

The experiment consisted of 24 plots. Each plot consisted of six rows, each 10 m long spaced 0.8 m apart, with total area per plot =48m². The evaluations were performed on two central rows, disregarding two guard rows on each side of the block and a half meter at each end of the row, with total evaluation area perplot = 14.4 m². The rates of the fertilizers were estimated according to Souza; Lobato (2004) recommendations for a mineral fertilizer. The NPK mineral fertilizer used in the experiment was a 3-32-6 formulation of urea, triple superphosphate and potassium chloride, with 6.7% N, 78% $P_2O_5$and 10.3% K_2O, respectively. The organo-mineral fertilizer was produced from poultry manure obtained from farms in the region. The production involved composting of the organic waste by means of controlled aerobic decomposition which lasted, on average, 20 days. Nutrient cocktails and microorganisms (fungi and bacteria) were used to accelerate the decomposition process, yielding a stabilized material. Next, the compost was amended with urea, triple superphosphate and potassium chloride to balance the nutrients. The additions were made according to nutritional requirements of potato plants, soil fertility and soil nutritional status. Finally, the material was homogenized and pelletized (Teixeira, 2013).

Table 2. Chemical parameters of organo-mineral and mineral fertilizer used in the cultivation of Agata

Nutrientes	Mineral	Organo-mineral
	%	
Calcium	2,00	1,40
Sulfur	2,00	1,40
Magnesium	1,50	1,10
Boron	0,20	0,14
Copper	0,10	0,07
Manganese	0,15	0,11
Zinc	0,14	0,14

The granules possessed a high degree of hardness (8 kgf cm^{-2}), which creates high resistance to breakage and prevents formation of irregular particles. The organic material in the fertilizer: (i) provides physical protection, (ii) forms a porous matrix for the nutrients, and (iii) prevents direct contact of soluble nutrients with the soil. As a result, it promotes lower fixation and leaching losses (Teixeira, 2013). Chemical characterization of the organo-mineral fertilizer used in the experiments is presented in Table 2. Soil preparation was done according to the recommendations for potato crops, with the following tillage operations: plowing, harrowing and furrowing (FILGUEIRA, 2008). Fertilization was performed manually using hoes to incorporate the fertilizer into soil. Agata type 3 seed tubers (30-40 mm diameter) were planted in furrows. Additionally, an application of 30 kg ha^{-1} of a fertilizer containing 2.7% Ca, 8.2% S, 12% Zn and 6 % Bwas carried out at planting on all plots, according to the recommendations by Souza and Lobato (2013). Hilling was performed about 30 days after planting in two seasons to stimulate tuberization. Hilling of the winter crop was additionally accompanied by topdressing with 300 kg $ha^{-1}$of 20-00-20 formulation, justified by low rainfall during the period. A central pivot irrigation system was used. The plants received approximately 500 mm of water during the cycle –a suitable volume for potato crops, which ranges between 450 and 550mm (Grimm *et al*., 2011). The data were submitted to analysis of variance to verify the existence of differences among the treatments. The comparison of the means from the treatments was carried out using the Scott Knott test at 0.05 significance and the SISVAR software (Ferreira, 2000). The data obtained from the treatments were submitted to polynomial regression analysis, also using the SISVAR statistical program.

RESULTS AND DISCUSSION

Significant differences among the treatments were observed regarding the average accumulation of macronutrients in tops (leaves and stems) and in tubers during the potato production cycle, (Table 3). The average accumulation of N in the leaves, and Ca and P in the stems in the treatment with the mineral fertilizer was higher relative to the treatment with the organo-mineral fertilizer. On the other hand,the accumulation of K and P in the tubers was statistically equal to theorgano-mineral treatment. The treatments produced the following accumulation of K: treatment 3 = 60%, treatment 5 = 100%, and treatment 6 = 120%; and accumulation of P:treatment 2 = 40%, and treatment 3 = 60%. Studies by Gonçalves *et al*. (2007) and Arimura *et al*. (2007) demonstrated higher yields of potato cultivars (Atlantic and Agata) treated with organo-mineral fertilizers, which was probably due to higher uptake of nutrients. Other studies, such as Luz *et al*. (2010), also showpositive effect of liquid organo-mineral fertilizers on vegetative growth of lettuce (Vera cultivar). Luz *et al*. (2010) observed that the use of biofertilizer in tomato (Deborahcultivar) led to better stability and quality of fruits in the upper bunches, which according to the literature should occur otherwise. When comparing the total average accumulation of macronutrients in the treatments with mineral and organo-mineral fertilizers, it is important to highlight that only the average accumulation of P provided with the mineral fertilizer was statistically equal to treatments 3, 5 and 6 (60, 100, 120%), i.e. there was a higher uptake of nutrients when they were delivered via organo-mineral fertilizer. According to Luz *et al*. (2010), the positive effect of the organo-mineral fertilizer is directly linked to compounds in its

Table 3. Accumulation of macronutrients by Agata potato cultivar for treatments with organo-mineral and mineral fertilizer

	Nitrogen (kg ha^{-1})				Phosphorus (kg ha^{-1})			
Treatment	Stems	Leaves	Tubers	Total	Stems	Leaves	Tubers	Total
1	15.01 a	26.65 e	0.64 a	42.31 b	1.11 d	1.39 b	1.84 c	4.34 c
2	16.11 a	19.85 b	4.49 b	40.45 a	1.04 d	2.07 d	1.62 c	4.72 c
3	21.05 c	25.41 d	6.96 c	53.42 d	0.45 a	1.66 c	1.62 c	3.72 b
4	18.85 b	30.65 f	4.94 b	54.44 d	0.54 b	2.64 f	1.31 b	4.49 c
5	14.37 a	24.69 c	5.26 b	44.33 c	0.55 b	2.24 e	0.90 a	3.69 b
6	15.56 a	18.80 a	4.76 b	39.13 a	0.64 c	1.12 a	1.14 b	2.90 a
CV (%)	11.79	3.24	26.08	4.23	14.49	8.69	25.5	8.81
	Potassium (kg ha-^{1})				Calcium (kg ha-^{1})			
Treatment	Stems	Leaves	Tubers	Total	Stems	Leaves	Tubers	Total
1	38.27 b	25.96 a	39.96 b	104.20 b	11.77 d	14.91 a	2.27 b	28.95 b
2	41.79 c	33.90 c	31.69 a	107. 39 b	8.65 a	17.02 b	4.29 c	29.97 b
3	16.60 a	36.24 d	37.51 b	90.34 a	10.81 c	18.81 c	3.87 c	33.50 c
4	55.79 e	39.44 e	27.45 a	122.67 c	10.50 c	27.33 d	2.75 b	40.58 d
5	50.87 d	29.60 b	36.23 b	116.70 c	8.13 a	14.26 a	2.63 b	25.03 a
6	52.15 d	26.30 a	40.12 b	118.58 c	9.46 b	17.49 b	1.33 a	28.30 b
CV (%)	8.95	3.11	22.94	6.84	11.09	8.01	27.17	5.89
	Magnesium (kg ha^{-1})				Sulfur (kg ha^{-1})			
Treatment	Stems	Leaves	Tubers	Total	Stems	Leaves	Tubers	Total
1	7.14 a	4.40 a	15.05 b	26.59 a	15.46 c	11.99 a	6.48 a	34.37 c
2	7.16 a	4.18 b	17.50 c	28.85 a	16.85 d	12.60 b	8.72 c	38.17 d
3	8.96 b	5.92 d	21.78 d	36.67 c	17.75 d	15.58 d	11.54 e	44.87 e
4	9.72 c	7.66 c	15.51 b	32.90 b	21.03 e	23.07 e	11.21d	55.32 f
5	8.57 b	5.26 a	10.95 a	24.78 a	10.47 b	11.65 a	7.70 b	29.83 a
6	10.98 d	4.54 b	12.32 a	27.85 a	8.31 a	14.47 c	8.79 c	31.57 b
CV (%)	9.54	5.80	27.39	13.58	9.69	6.46	1.88	3.44

Means followed by the same letter do not differ by the Scott Knott test (1974)at 0.05 % significance.

Table 4. Adjustment of polynomial regression equations for macronutrient accumulation in leaves, stems, tubers and total of potato plants in winter crop

Macronutrient	Plant part	B_0	$^1B_1$	$^2B_2$	R^2 (%)
Nitrogen	Leaves	-42.27	2.34	-0.02	65.78
	Stems	-46.47	2.28	-0.02	90.13
	Tubers	-5.08	0.15	0.00003	98.78
	Total	-93.82	4.76	-0.04	81.75
	Leaves	-7.06	0.33	-0.003	92.99
Phosphorus	Stems	-2.63	0.12	-0.001	98.45
	Tubers	0.44	-0.04	0.001	99.81
	Total	-9.28	0.42	0.00011	94.36
	Leaves	-52.96	3.42	-0.03	96.40
Potassium	Stems	-155.62	7.36	-0.06	92.27
	Tubers	-41.43	1.17	0.0003	99.74
	Total	-250.02	11.95	-0.09	99.49
	Leaves	-35.95	1.97	-0.02	98.10
	Stems	-23.10	1.21	-0.01	94.83
	Tubers	0.73	-0.07	0.001	99.74
	Total	-58.33	3.11	-0.02	97.37
Calcium	Leaves	-11.04	0.62	-0.005	93.16
	Stems	-22.3	1.12	-0.01	88.95
	Tubers	0.45	-0.25	0.01	99.94
	Total	-32.71	1.49	-0.01	99.93
Sulfur	Leaves	-25.80	1.48	-0.011	67.33
	Stems	-46.82	2.25	-0.02	93.86
	Tubers	10.33	-0.07	0.001	93.94
	Total	-61.68	-3.63	-0.03	80.98

*: significant at 0.05; 1: $y= B_0+B_1x$; 2: $y= B_0+B_1x+ B_2x^2$

Table 5. Translocation of macronutrients in each treatment, total yield of tubers and the average translocation of nutrients per ton of tubers, evaluated 89 days after planting

Treatment	Translocation of macronutrients (kg ha^{-1})						Total yield (ton ha^{-1})
	N	P	K	Ca	Mg	S	
1	1.17 a	3.99 c	71.98 b	4.13 b	31.75 b	7.75 a	43.12 a
2	8.38 b	3.57 c	54.40 a	9.88 e	36.55 c	9.56 c	41.52 a
3	14.64 d	3.75 c	77.01 b	8.59 d	49.73 d	13.14 e	42.50 a
4	8.38 b	2.68 b	45.44 a	5.64 c	32.38 b	11.92 d	42.94 a
5	10.29 c	2.12 a	68.15 b	5.68 c	22.00 a	7.64 a	42.50 a
6	7.00 b	2.05 a	68.31 b	2.42 a	21.94 a	8.70 b	34.87 a
DP*	8.50	3.80	65.08	5.42	33.67	12.02	41.24
	Mean translocation of nutrient per ton of tubers in kg ha^{-1}						
	N	P	K	Ca	Mg	S	
[4]Mean	0.20	0.07	1.49	0.15	0.79	0.24	

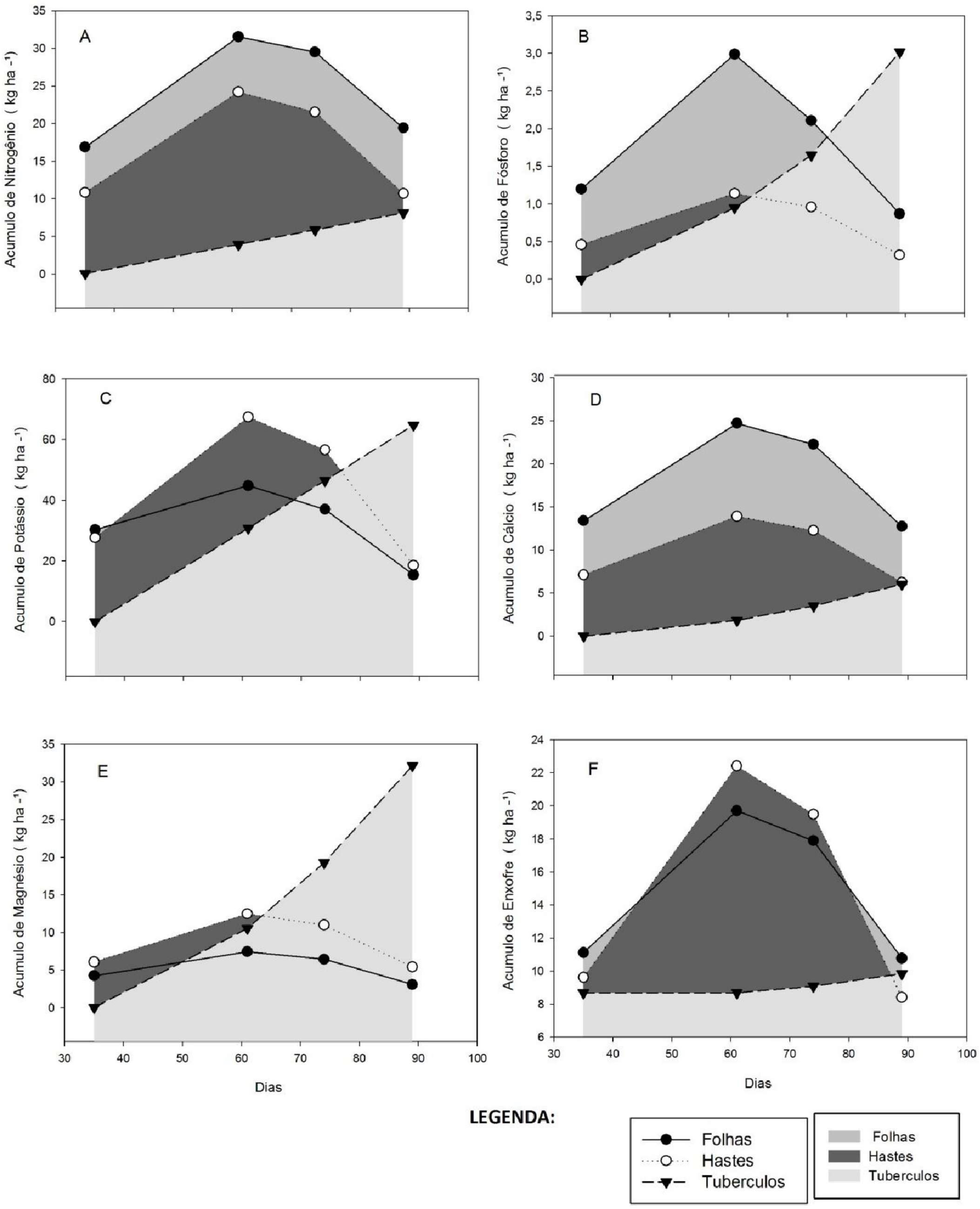

Figure 1. Accumulation of nutrients in leaves stems and tubers of potato during the production cycle

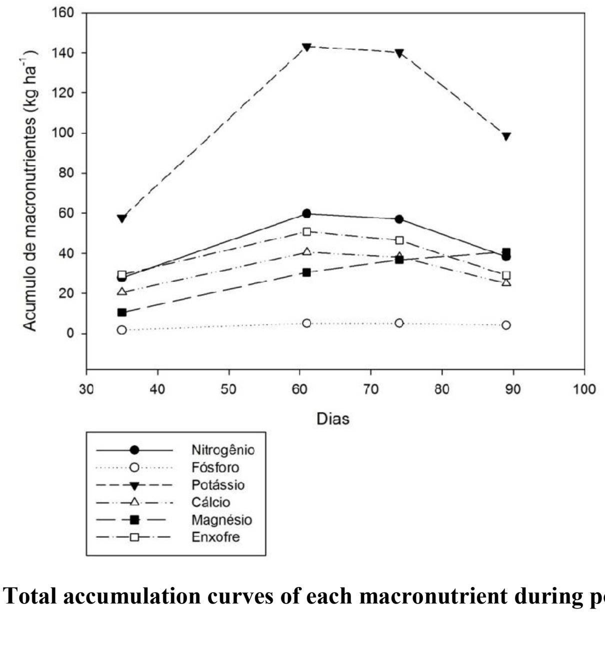

Figure 2. Total accumulation curves of each macronutrient during potato cycle

composition which generally optimize the absorption of nutrients. Some studies have shown that the application of organo-mineral fertilizers improve crop productivity and plant morphological parameters such as length and diameter of roots (Bruno *et al*, 2007; Oliveira *et al*, 2007), as well as nutrient concentration in roots (Pedrosa *et al*., 2007), thus improving nutrient uptake efficiency. Table 3 shows that the potato plants in the organo-mineral treatment 4 (80%) absorbed the highest average amount of all macronutrients, except P. There, we also find that treatment 3 (60%) demonstrated higher absorption of macronutrients relative to the mineral fertilizer, except for the total accumulation of K and P, which were statistically equal. Kaseker *et al*. (2014), evaluating the application of organo-mineral fertilizers in carrot, also noted an increase in accumulation of nutrients in plants in a highly fertile soil - conditions similar to this study. Figure 1 (A, B, C, D, E, F) shows accumulation curves of primary and secondary macronutrients in potato leaves, stems and tubers in the organo-mineral treatment along the crop cycle. Figure 2 shows total accumulation curves (sum of stems, leaves and tubers)along the crop cycle. The parameters of regression equations for all curves are in Table 4. Maximum accumulation of N, P, K, Ca, Mg, and Sin leaves and stems occurred 61 days after planting (Figure 1 A, B, C, D, E and F). Afterward, decreasing values were observed, which is probably due to translocation of nutrients to tubers (Fernandes *et al*. 2011). Cabalceta *et al*. (2005) found that N, P and K absorbed by potatoes in the early stages of the production cycle are accumulated mainly in the tops. However, in the final phase of the cycle, most of the shoot nutrients are translocated to tubers. The same authors also report that Mg and S accumulated in the tops are translocated to tubers in the final phase of the cycle. On the other hand, even though part of Ca is also translocated to tubers, a large amount of it remains in the aerial part of the plant. According to Fernandes *et al*. (2010), falling leaves and translocation of N, P, K, Mg and S to the tubers decrease nutrient levels in leaves. Reduced Ca levels in leaves at the final stage occur, however, mainly due to senescence and also leaf fall, since Ca has low redistribution capacity in the plant.

It is noteworthy that there was a growing accumulation of macronutrients along the cycle in the tubers (Figure 1 A, B, C, D, E, F). Regarding Mg, its accumulation exceeds the sum of the accumulation in leaves and stems, as it can be seen by comparing Figures 1 and 2. Figure 2 shows that the accumulation of nutrients by potato plants in the organo-mineral treatment grew up to 61 days after planting. Only Mg demonstrated growing accumulation up to 89 days after planting, as already pointed out. Similar results were obtained by Fernandes *et al*. 2011 when working with different potato cultivars. Those authors found growing accumulation of macronutrients up to 65 days after planting, including Mg. Figure 2 shows that the macronutrients absorbed in larger quantities obeyed the following order: K> N> S> Ca> Mg> P. Authors like Fernandes *et al* (2011), Nunes *et al*, 2006; Alvarado *et al*., 2009), revealed that K and N are the most required elements by potato plants. The accumulation of nutrients varies according to: productivity, season, environmental conditions, and plant development phase; which occur during vegetative growth and intensify during flowering and formation of fruits and tubers. (Cardoso, 2014) The maximum total accumulation depends on the demand for nutrients during the crop cycle. (Cardoso, 2014). Maximum accumulation of N, P, K, Ca, Mg and S was 59.70 kg ha^{-1}, 5.18 kg ha^{-1}, 143.20 kg ha^{-1}, 40.49 kg ha^{-1}, 40.72 kg ha^{-1} and 50.75 kg ha^{-1}, respectively (Figure 2). Results for N and K were similar to those observed by Fernandes *et al*. 2010, who registered 59.23 kg ha^{-1} of N and 154.23 kg ha^{-1} of K. Maximum accumulation of P was within the range observed by Cardoso (2014). The authors studying various rates of organo-mineral fertilizer applied to potato (Atlantic cultivar) found accumulations between 4 and 14 kg ha^{-1}.Sulfur accumulation was almost equal to the maximum level (53.80 kg ha^{-1}) observed by Cardoso (2014). The maximum Ca accumulation was close to the level which was found by Fernandes *et al* (2011) (34 kg ha^{-1}) for Agata cultivar. In the same study the authors found values of 50 and 53 kg ha^{-1} of accumulated Ca in Asterix and Mondial cultivars, respectively. The maximum accumulation of Mg in this study was higher than that found by Fernandes *et al* (2011), Cardoso (2014) and Yorinori (2003), who found values close to 14 kg ha^{-1}. The accumulation of nutrients in the tubers at the end of the cycle corresponds to the total of the cycle. There was a statistically significant difference among treatments with organo-mineral and mineral fertilizers. However, no significant differences among total yield of tubers per hectare were observed (Table 5). The average translocation of nutrients with the organo-mineral treatment corresponded to 14%, 73%, 45%, 13%, 83% and 24% of total N, P, K, Ca, Mg and S (respectively) accumulated by the potato in this study. These results differ from results obtained by Yorinori (2003), who found translocation of 80-94% P, 68-74% N 32-57% S, 25.5% Mg, 19-20% K and 2.8-3.6% Ca with mineral fertilizers. Fernandes *et al*. (2011) found translocation of 66% N, 84% P, 87% K, 6% Ca, 65% Mg and 64% S. Thus, it can be seen that the results vary widely depending on the conditions. It is also noteworthy that there is no data in the literature to compare organo-mineral fertilizers. The average translocation of nutrients per ton of tubers per hectare differs largely in the literature. For example N values range between 0.87 kg t^{-1} (Paula *et al*. 1986) and 5.55 kg t^{-1} (Jackson and Haddock, 1959).More recently, values between 2.12-2.4 kg t^{-1}have been observed by Fernandes *et al*. (2011), and 3.2 kg t^{-1} by Reis Júnior; Monnerat, (2001).In this study the average translocation of nitrogen was 0.2 kg t^{-1} (Table 5).

The translocation per ton of all macronutrients is shown in Table 5.The translocation of N, P and K in this study with organo-mineral fertilizer was smaller than translocation observed in some studies as Fontes (1997) and Yorinori (2003). Those authors found average P translocation values between 0.3 and 0.6 kg t^{-1}, and K translocation from 2.88 to 4.46 kg t^{-1}. Ca translocation in this study (Table 5) was higher than 0.07-0.08 kg t^{-1}reportedby Yorinori (2003), and lower than 0.5-1.5 kg t^{-1} found by Fontes (1997). However, our results closely matched 0.10 kg t^{-1} found by Fernandes *et al*. (2011). Still, Mg translocation was about 4 times higher than the amount obtained by Fernandes *et al*. (2011).The level of S translocation asidenticalto translocation obtained by Yorinori (2003); however, it was outside the range of 0.3-0.8 kg $t^{-1}$of S found by Fontes (1997). These results show the need to further investigate the behavior of organo-mineral fertilizers in the soil system. Also, the results obtained in this study differ widely from the results found in the literature regarding the use of mineral fertilizers. Thus, more studies in different soil, climate and management conditions are necessary to better understand the effects of organo-mineral fertilizers on soil and crops.

Conclusions

The average accumulation of nutrients in potato plants was higher in treatments with organo-mineral fertilizer. The amount of absorbed macronutrients obeyed the following decreasing order: K> N> S> Ca> Mg> P. Tuber yields for the organo-mineral treatments were identical to the treatment with conventional mineral fertilizer, including the treatment corresponding to 40% of mineral fertilizer, which demonstrates high efficiency of organo-mineral fertilizers. The average translocation of macronutrients in treatments with organo-mineral fertilizers corresponded to 14% N, 73% P, 45% K, 13% Ca, 83% Mg and 24% S accumulated by potato plants during the production cycle.

REFERENCES

Alvarado, A, Iturriaga, I., Smyth, J.T., Ureña, J.M. and Portuguez, E. 2009. Efecto de lafertilización com fósforo sobre elrendimiento y laabsorción de nutrimentos de la papa enunandisol de Juan Viñas, Costa Rica. Agron. Costarricense*33*:45-61

Arimura, N. T., Arreon, R., Luz, J.M.Q, Guirelli, SILVA, P.A.R. and Silva, M. A. D. 2007. Influência da aplicação de produtos organomineraisAminoagro na produção de batata, cv. Ágata. Paperpresentedat: Encontro nacional da produção e abastecimento de batata (Holambra, Brazil, ABBA).

Bertsch, F. 2003. Absorción de nutrimentos por los cultivos, 1 ed (San José, Costa Rica: ACCS), pp. 307.

Bruno R. L. A., Viana, J.S., Silva, F.V., Bruno, G.B. and Moura, M.F. 2007. Produção e qualidade de sementes e raízes de cenoura cultivada em solo com adubação orgânica e mineral. Horticultura Brasileira *25*:170-174

Cabalceta, G., Saldias, M. and Alvarado, A. 2010. Absorción de nutrientes enelcultivar de papa MNF-80. Agron. Costarricense*29*:107-123

Cardoso, A. F. 2014. Fertilizante Organomineral em Batata cv, Atlantic: produtividade e crescimento e acumulo de nutrientes em diferentes safras de plantio. Paperpresentedat: Dissertação de mestrado em fitotecnia (Uberlândia, Brazil, UFU).

Donagema, G. K., Campos, D.V.B., Calderano, S.B., Teixeira, W.G. and Viana, J.H.B. 2011. Manual de métodos de análise de solos.2. ed. (Rio de Janeiro: EMBRAPA SOLOS), pp. 230.

FAOSTAT **-** Food and Agriculture Organization of the United Nations 2015. www.faostat.fao.org

Fernandes, A. M., Soratto, R. P and Silva, B. L. 2011. Extração e exportação de nutrientes em cultivares de batata: I - macronutrientes. Rev. Bras. Ciênc. Solo*32*: 2039-2056

Fernandes, A.M., Soratto, R.P., Silva, B. L. and Souza-Schlick, G.S. 2010. Crescimento, acúmulo e distribuição de matéria seca em cultivares de batata na safra de inverno. Pesq. Agropec. Bras.*45*:826-835

Ferreira, D. F. 2010. SISVAR – Sistema de análise de variância**.** Versão 5.3, (Lavras: UFLA).

Fontes P.C.R. and Pereira P.R.G. 2003. Nutrição mineral do tomate para mesa. Informe agropecuário*24*: 27-34

Fontes, P.C.R. 1997. Preparo do solo, nutrição mineral e adubação da batateira. 1 ed. (Viçosa: UFV) pp.42.

Gonçalves, M. V., Carreon, R., Luz, J.M.Q., Guirelli, J.E., Silva, P.A.R. and Silva, M.A.D. 2007. Produção de batata. cv. Atlantic, submetida a produtosoganominerais Aminoagro. Paper presented at: Encontronacional da produção e abastecimento de batata (Holambra, Brazil, ABBA).

Grimm, E. L., Heldwein, A., Radons, S.Z., Maldaner, I.C., Trentin, G. and Bosco, L.C. 2011. Produtividade da batata em função da irrigação e do controle químico da requeima. Rev. bras. eng. agríc. Ambiente *15*: 125-130

Jackson, R. D. and Haddock, J. L. 1959. Growth and mineral uptake of Russet Burbank potatoes. American Potate Journal*36*: 22-28

Kaseker, J. F., Bastos, M.B., Consalter, R. and Mogor, A.F. (2014). Alteração do crescimento e dos teores de nutrientes com utilização de fertilizante organomineral em cenoura. Rev. Ceres 61: 964-969

Luz, J. M. Q., Bittar, C., Queiroz, A.A. and Carreon, R. 2010. Produtividade de tomate 'Débora Pto' sob adubação organomineral via foliar e gotejamento.Hortic. Bras*28*: 489-494

Luz, J. M. Q., Oliveira, G., Queiroz, A. A. and Carreon, R. 2010. Aplicação foliar de fertilizantes organominerais em cultura de alface. Horticultura Brasileira *28*: 373-377

Macedo, M.C.M., Haag, H. P. and Gallo, J.R. 1977. Nutrição mineral de hortaliças.:XXI Absorção de nutrientes por cultivares nacionais de batatinha (*Solanumtuberosum*L.). Anais ESALQ *34*:179-229

Miranda Filho, H. S. da, Granja, N.P.doand Melo, P.C.T. de. 2003. Cultura da batata.1. ed. (Vargem Grande do Sul: FAEF), pp.68.

Nunes, J.C.S., Fontes, P.C.R., Araújo, E. F. and Sediyama, C. 2006. Potato plant growth and macronutrient uptake as affected by soil tillage and irrigation systems. Pesq. Agropec. Bras. 41:1787-1792

Oliveira A. P., Barbosa, A. H. D., Cavalcante, L.F., Pereira, W. E. and Oliveira, A. N. P. 2007. Produção da batata-doce adubada com esterco bovino e biofertilizantes. Ciência Agrotécnica 31: 1722-1728

Paula, M. B., Fontes, P. C. R., Nogueira, F. D. 1986. Produção de matéria seca e absorção de macronutrientes por cultivares de batata. Horticultura Brasileira*4*: 10-16

Pedrosa M.W., Sediyama, M.A.N., Vidigal, S.M., Salgado, L.T., Oliveira, F. and Nobre, M.C. 2007. Concentração de nutrientes em raízes de três cultivares de cenoura, adubadas com diferentes rates de compostos orgânicos. Revista Brasileira de Agroecologia 2: 1145-1149

Reis Júnior, R.A. and Monnerat, P.H. 2001. Exportação de nutrientes nos tubérculos de batata em função de rates de sulfato de potássio. Hortic. Bras. *19*: 360-364

Soratto, R. P., Fernandes, A. M., Souza-Schlick, G.D. 2011. Extração e exportação de nutrientes em cultivares de batata: II - micronutrientes. Rev. Bras. Ciênc. Solo*35:* 2057-2071

Sousa D.G and LOBATO, E. 2004. Cerrado: correção do solo e adubação. 2 ed. (Planaltina: EMBRAPA Cerrados) pp.416.

Souza J.L. and Resende P. 2003.Manual de horticultura orgânica. 1 ed. (Viçosa: Aprenda fácil), pp. 564.

Teixeira, W. G. 2013. Biodisponibilidadde de fósforo e potássio de fertilizantes mineral e organomineral. Paper presented at: Dissertação de mestrado em fitotecnia (Uberlândia, Brazil, UFU).

Yorinori, G.T. 2003. Curva de crescimento e acúmulo de nutrientes pela cultura da batata cv. 'Atlantic'. Paper presented at: Dissertação de mestrado em fitotecnia (Piracicaba, Brazil, ESALQ).

Zobiole, L.H.S., Castro, C., Oliveira, F.A. and Oliveira Junior, A. 2010. Marcha de absorção de macronutrientes na cultura do girassol. *R. Bras. Ci.* Solo 34:425-433

****