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Export and nutrient partitioning in organic onion

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ABSTRACT

Early season onion crop, despite lower yield, is an opportunity for farmers to explore market and better prices in southern Brazil. Knowing the amount absorbed and the distribution of nutrients in the plant is essential for adequate management of fertilization. However, little information on this matter is available for onion, especially for organic farming and nontraditional periods in southern Brazil. The objective of this study was to evaluate the nutrient absorption and partitioning in open-pollinated onion cultivars grown in organic system. The experiment was conducted in the Canguiri-UFPR experimental organic farm, Curitiba-PR, with sowing in January. The experiment was arranged in a completely randomized design with three replications. Cultivars Franciscana IPA-10 (purple), Vale Ouro IPA-11 and Brisa IPA-12 (from Empresa Pernambucana de Pesquisa Agropecuária - IPA), Alfa Tropical (from Embrapa Hortaliças), Alfa São Francisco (VIII cycle) and Alfa São Francisco-RT (thrips resistant– genotype under test; from Embrapa Semi-árido), and BR-29 (Topseed-Agristar) were selected for the study. Chemical analyses were performed for shoot and bulbs collected at harvest. The production potential of cultivars varied, and the most productive ones were the most efficient in converting the nutrients absorbed in bulb yield. The order of nutrient contents in the shoots was K > N > P > Ca > Mg > Fe > Zn > Mn = B > Cu, whereas in the bulbs it was K > N > P > Ca > Mg > Fe > B > Zn > Cu > Mn. Nutrients were required in the following order of amount K > N > P > Ca > Mg > Fe > Zn > B > Mn > Cu, per ton of fresh bulbs, and accumulated in greater quantity in the shoot, except Zn, which had higher concentration in the bulb.

Keywords: *Allium cepa*; Onion nutrition; cultivars.

RESUMO

Extração e partição de nutrientes em cebola cultivada no sistema orgânico

O cultivo da cebola em época antecipada, apesar da menor produtividade, representa oportunidade de melhores mercado e preço aos agricultores do sul do Brasil. Conhecer a quantidade absorvida e a distribuição dos nutrientes na planta nesta condição é essencial para o manejo adequado da adubação. Para a cebola poucas informações estão disponíveis, especialmente para o cultivo orgânico e plantio em época antecipada na região sul do Brasil. O presente trabalho foi conduzido na área experimental de olericultura orgânica da estação do Canguiri-UFPR, região metropolitana de Curitiba, com o objetivo de avaliar a absorção de nutrientes e a partição destes em cultivares de cebola de polinização aberta, em sistema orgânico, com semeadura em janeiro. O delineamento experimental foi inteiramente casualizado, com três repetições. As cultivares avaliadas foram: Franciscana IPA-10, Vale Ouro IPA-11, Brisa IPA-12, Alfa Tropical, Alfa São Francisco, Alfa São Francisco-RT e BR-29. Foram realizadas análises químicas da parte aérea e dos bulbos coletados

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no momento da colheita. As cultivares variaram quanto ao potencial produtivo, sendo as mais produtivas mais eficientes em converter nutrientes absorvidos em produção de bulbos. O conteúdo de nutrientes ocorreu na seguinte ordem: parte aérea –K > N > P > Ca > Mg > Fe > Zn > Mn = B > Cu; bulbos – K > N > P > Ca > Mg > Fe > B > Zn > Cu > Mn. Por tonelada de bulbos frescos produzida, os nutrientes foram requeridos na seguinte ordem de quantidade K > N > P > Ca > Mg > Fe > Zn > B > Mn > Cu e, acumularam-se em maior quantidade na parte aérea, exceto o Zn, que apresentou maior concentração no bulbo.

Palavras-chave: *Alium cepa*. Nutrição de cebola. Cultivares.

INTRODUCTION

Onion (*Allium cepa*) is a very important commercial crop in Southern Brazil. Currently, the region accounts for 52% (747,133 ton) of the total produced in the country (1,444,146 tons), with 376,603 tons produced in Santa Catarina, followed by Rio Grande do Sul with 207,089 tons, and Paraná with 163,441 tons (IBGE, 2012). With a cultivated area of 7637 ha, the state of Paraná is the sixth largest producer, with 65% of production coming from the Metropolitan Region of Curitiba (RMC), equivalent to approximately 130,200 ton (SEAB/DERAL, 2009).

However, because of the off-season period from June to September, the state of Paraná needs to import onion from São Paulo and Santa Catarina, as well as from other countries, mainly Argentina (40,500 ton) (CEPA, 2012). A way to meet this demand is the introduction of new cultivars adapted to a nontraditional crop period.

In addition, since much of the RMC is currently considered environmental protection area (State Law No. 12,248/98), any cultivation must be in the organic system, which demands greater adaptation to climate, nutrient absorption capacity and disease resistance of the crops to be implemented.

The production of organic onions is an alternative to be considered, aiming to meet the growing consumers' demand for organic farming products, with higher benefit and attractive features such as the white and purple varieties, with specific market niches (Boeing, 2002).

According to Melo & Ribeiro (1990), the onion germplasm is made up of local populations and cultivars developed over centuries to adapt to different latitudes, farming systems and local consumer preferences. Assessing these characteristics, the Instituto Agronômico de Pernambuco – IPA (Pernambuco Agronomic Institute) in partnership with Embrapa Semi-Árido Unit, developed onion breeding programs (Buzar *et al*., 2007), resulting in the IPA cultivars. Another national breeding program, developed by Embrapa Semi-Árido, along with Embrapa Hortaliças Unit (Embrapa Vegetables Crop Unit) produced the Alfa Tropical cultivars, and more recently the Alfa São Francisco.

When introducing new cultivars in a region, besides evaluating their adaptability to environmental conditions and the farming system, one also should consider their nutritional requirements, as these traits are genotypically different and reflect the growth and final yield of the species (Vidigal *et al*., 2003).

Partitioning or distribution of nutrients in different parts of the plant is important to estimate the export and return of nutrients to the soil (May *et al*., 2008). The little information on nutrient uptake by onion grown in Brazil indicates that K followed by N and Ca are the most absorbed nutrients (Pôrto *et al*., 2006, Vidigal *et al*., 2010), and that the nutrients N, P, K and S accumulate preferentially in the bulb, while Ca and Mg in the shoots (Pôrto *et al*., 2006). Regarding micronutrients, Vidigal *et al*. (2000) reported that the bulb accumulated most of Zn, Fe and B, while Alloway (2004) found that the onion is demanding in Zn, Mn, Cu and Mo, but little susceptible to B deficiency. Vidigal *et al*. (2010) reported that the cultivar Alfa Tropical had the following order of nutrient absorption: Fe > Mn > Cu > Zn, in Minas Gerais. It is known that both the absorbed amount and distribution of nutrients in the plant varies among cultivars (Santos *et al*., 2007).

In Brazil, data on nutrient export in onions are scarce, particularly micronutrients and especially in organic farming.

The present study aimed to determine the absorption and nutrient partitioning between shoot and bulb in open-pollinated onion cultivars in organic system, off the traditional growing season.

MATERIAL AND METHODS

The experiment was conducted at the Canguiri Experimental Farms of the Federal University of Paraná, in municipality of Pinhais, metropolitan region of Curitiba (25°25' S and 49°08' W, 930 m altitude), from January to August 2009. The climate, according to Köppen, is subtropical Cfb, with monthly rainfalls of 135.2; 160.6; 118.4; 13.4; 41.6; 70.2; 265.6 and 102.0 mm between January and August 2009. The monthly temperature averages for the same period were: 19.0; 19.0; 19.1; 16.0; 14.0; 10.2; 10.9 and 12.9 °C respectively (Simepar, 2010). The average photoperiod of the region during the trial period was 11:40 h (Simepar, 2010).

The soil of the experimental area is classified as alic Oxisol with clayey texture and wavy relief. The chemical analysis of the 0-15 cm layer showed 6.1 pH ($CaCl_2$); 0 Al^{3+}, 3.7 H+Al, 7.2 Ca, 3.4 Mg, 1.44 K and 15.74 $cmol_c$ dm^{-3} CTC, 158.4 mg dm^{-3} P, 37.4 g dm^{-3} C; 0.98 mg dm^{-3} B and 76% V.

The experiment was arranged in a was completely randomized design with three replications and seven treatments with the open-pollinated onion cultivars Franciscana IPA-10 (purple), Vale Ouro IPA-11, Brisa IPA-12, Alfa Tropical, Alfa São Francisco, Alfa São Francisco-RT, and BR-29. Seeds were sown in January and plants were harvested in August, 2009. Seedlings were obtained by the sowing and transplanting method. Sowing was carried out off the time recommended for the region, between June and July, and harvest between November and January (Mendonça *et al.*, 2004).

The soil was prepared 15 days before transplanting the seedlings. Fertilization followed Raij *et al*. (1996) recommendations for onion crop, including 200 kg ha^{-1} of magnesium thermophosphate (17% P_2O_5) and 8 t ha^{-1} of compost, which had the following average values N= 14.4 g kg^{-1}; P= 10.6 g kg^{-1}; K= 11.3 g kg^{-1}; Ca= 31.7 g kg^{-1}; Mg= 6.8 g kg^{-1}; C= 384 g kg^{-1}; pH= 7.1; C/N= 27.6. Later, row beds were prepared with a raised bed maker, enabling fertilizer application.

Four 30-cm-apart rows were prepared per raised bed, plants were spaced 15 cm apart, in 1.20 x 4.05 m plots with 104 plants. The plot harvest area consisted of the two central rows by 3.5 m. Seedlings were transplanted on March 20, 2009 (55 days after sowing). At 40 days after transplantation, 80 kg ha^{-1} of potassium sulfate (50% K_2O and 17% S) was applied to the soil.

Harvest was carried out at 99 days after transplanting (DAT), when about 75% of the plants reached the popping stage. Yield was expressed in kg per hectare of bulb fresh matter. The bulbs were separated from shoots at leaf insertion, dried in an forced air circulation oven at 60 °C for 72 h, and weighed. The results were extrapolated to hectare. The harvest index was calculated by dividing bulb dry matter by mass of total dry matter (shoot + bulb).

At the harvest day, four plants were collected from the plot harvest area, washed in deionized water, separated into shoot and bulb without roots, and dried in a forced air circulation oven to constant weight. After drying and weighing, the material was ground for chemical analysis. Chemical analyses of tissue were performed at the Biogeochemistry Laboratory of the Department of Soil Science and Agricultural Engineering - UFPR, according to Martins & Reissmann (2007), except for boron, which was performed according to Bataglia *et al*. (1983). N content was determined by dry combustion (975 ºC), using the Vario El III CHNOS Elemental Analyzer.

Extraction and export of nutrients were obtained by multiplying the nutrient content by the dry matter yield of each part of the plant. For extraction, it was considered the sum of the nutrients present in the bulbs and shoots, while for export, it was considered only the bulbs.

Data variances were tested for homogeneity using the Bartlett's test and the treatment means were compared by the Tukey's test at 5% probability. Data was analyzed by the M-STAT software, version 2.11 (Michigan State University, 1989).

RESULTS

The highest bulb mean yields were recorded for cultivars Alfa São Francisco-RT followed by Alfa São Francisco and Alfa Tropical, and the lowest yields for cultivars BR-29 and IPA-10. Shoot yield ranged from 13,394 to 21,880 kg ha^{-1}, with cultivars BR-29 and Alfa Tropical higher than IPA-12 and IPA-10, but without differing from the others (Table 1). Bulb moisture ranged from 92.68 to 93.96%, and was close to shoot moisture, which was between 92.17 and 93.71%. The harvest index ranged from 0.23 for cultivar BR-29 to 0.48 (more than twice) for Alfa São Francisco - RT, and this index was directly proportional to yield (Figure 1).

The content of N and P did not vary among onion cultivars, both in the shoot and in the bulbs (Table 2), while the K content in shoot was highest in Alfa São Francisco-RT, followed by BR-29 and Brisa IPA-12, and lowest in Franciscana IPA-10. In the bulbs, K levels were highest in Alpha São Francisco-RT and lowest in Alfa Tropical (Table 2).

Ca contents in onion shoots were highest in Alfa São Francisco-RT and lowest in BR-29. In bulbs, Ca contents were highest in Franciscana IPA-10 and Brisa IPA-12 and lowest in Alfa São Francisco-RT, Alfa São Francisco and BR-29. The Mg content in the bulbs were similar among the cultivars, except for BR-29, which had the lowest content (Table 2).

Comparing shoots with bulbs, no difference was observed between the content of N and P, except for cultivar Alfa São Francisco-RT, which had the highest content of P in the bulbs. K, Ca and Mg contents were higher in the shoots, except for cultivar IPA 12, which had higher Mg content in bulbs (Table 2).

Most of the cultivars showed macronutrient content in the following order: K > N > P > Ca > Mg, both in shoots and bulbs. The exceptions were Franciscana IPA 10 and BR 29, which showed higher content of N than K, and Alfa São Francisco-RT that concentrated more Ca in shoots, with content of this nutrient greater than P in the shoot and the lowest content among the other cultivars in the bulbs.

Cu contents in onion shoots were highest in Vale Ouro IPA-11 and lowest in Franciscana IPA-10 and Alfa Tropical. In bulbs, Cu contents were highest in BR-29 and lowest in Vale Ouro IPA-11. Mn content in shoots was highest in Vale Ouro IPA-11 and lowest in Franciscana IPA-10, while in bulbs, this nutrient was highest in cultivar BR 29 and Vale Ouro IPA-11 and lowest in BR 29 (Table 2).

Fe was the micronutrient found in the highest content in onion, both in shoots and bulbs. In shoots, Fe contents were in highest in Franciscana IPA-10 and Alfa São Francisco-RT, and lowest in Alfa São Francisco and BR-29 (Table 2). In bulbs, this nutrient content divided the cultivars into two groups: cultivars Franciscana IPA-10, Vale Ouro IPA-11, Brisa IPA-12 and Alfa Tropical showed on average 2.5 times higher Fe content in this part of the plant than cultivars Alfa São Francisco, São Francisco Alfa-RT and BR-29.

The Zn content in shoots did not vary among cultivars. In bulbs, Vale Ouro IPA-11 showed higher content than the Brisa IPA-12. Unlike Zn, B content varied among cultivars only in shoots, being the lowest in cultivar BR-29 (Table 2).

In shoos, the decreasing sequence of micronutrient content was Fe > Zn > Mn = B > Cu in all cultivars, while in bulbs, the sequence was Fe > B > Zn > Cu > Mn, except for Vale Ouro IPA-11 with Mn content higher than Cu content.

In relation to the plant nutrient content, the least productive cultivars (Table 1), and especially BR 29, showed the largest amounts of nutrients extracted per ton of fresh bulb (Table 3). Likewise, the most productive cultivars (Table 1), especially Alpha São Francisco RT, accumulated the smallest amounts of nutrients per ton, therefore they were more efficient in nutrient use. The export of nutrients (content in bulbs) varied less than extraction among cultivars, especially macronutrients (Table 3), with no relation to bulb yield. Considering the average of all cultivars, about 36, 41, 32, 28, 31, 47, 27, 47, 68 and 31% of N, P, K, Ca, Mg, Cu, Mn, Fe, Zn and B, respectively, were allocated to the bulbs, that is, except for Zn, all nutrients are concentrated in greater amounts in the shoots of onion.

In general, both the level (Tables 2 and 3) and the content (Table 3) of nutrients were higher in the shoots of onion. However, the micronutrients Cu, Fe and B showed higher levels in the bulbs, but higher contents in the shoots, the opposite was true with Zn, which was the only nutrient that even with the highest level in the shoots showed higher content in the bulbs.

Regardless of the cultivars, the sequence of nutrients in relation to the amounts extracted (whole plant) was K > N > P > Ca > Mg > Fe > Zn > B > Mn > Cu. The amount considered as export (bulbs) also showed the same sequence for most cultivars, changing only for higher Cu values compared to Mn. The exceptions were cultivars Franciscana IPA 10 and BR 29, which had N export higher than K; however with very similar values. Cultivar BR 29 showed the following export sequence: Cu > B > Mn; and Vale Ouro IPA 11 had Mn export higher than Cu export (Table 3).

DISCUSSION

Variation of yield potential among cultivars was observed for organic and off-season farming in the southern region of Brazil, with cultivar Alfa São Francisco-RT showing the greatest yield potential. This higher yield potential is associated with the higher harvest index, i.e., greater portion of bulb mass relative to the total mass accumulated by the plant. Therefore, the higher bulb yield was not followed by shoot yield, suggesting that the leaf area in all cultivars was sufficient to meet demand

Table 1: Production of shoots and bulbs and harvest index (ratio between bulb yield and bulb + shoot yield) of onion cultivars in organic system and early planting in southern Brazil

Cultivar*	Shoot		Bulb		Harvest Index
	Fresh	Dry	Fresh	Dry	
	kg ha^{-1}				
IPA-10	13394 c	893 e	6032 d	472 c	0.35 c
IPA-11	20445 ab	1282 c	10896 c	802 b	0.38 c
PA-12	18061 b	1088 d	6246 d	449 c	0.29 d
A. Trop	21785 a	1388 ab	13746 b	1072 a	0.44 b
ASF VIII	18658 ab	1364 b	15458 b	1178 a	0.46 ab
ASF –RT	19396 ab	1207 c	18042 a	1133 a	0.48 a
BR-29	21880 a	1458 a	6388 d	438 c	0.23 e
Mean	19088	1240	10973	792	0.38
CV (%)**	6.37	2.30	6.55	5.99	4.01

*Cultivar: IPA-10=Franciscana IPA-10; IPA-11=Vale Ouro IPA-11; IPA-12=Brisa IPA-12, A. Trop=Alfa Tropical; ASF VIII=Alfa São Francisco – Ciclo VIII; ASF-RT=Alfa São Francisco – RT and; BR-29= BR-29. ** Coefficient of Variation (CV%). Means followed by the same letter in the columns are not significantly different by the Tukey test at 5% probability. Means followed by the same capital letter in the rows are not significantly different by the F test. Absence of capital letters indicates that there was no significant difference.

photosynthetic plants. The 18.04 ton ha^{-1} yield attained by cultivar Alfa São Francisco-RT enables the onion crop at this time, as reported by Bettoni *et al.* (2012), who obtained yields between 15 and 18 ton for cultivars Alfa São Francisco and Alfa São Francisco-RT.

The genetic variability among the cultivars did not affect N and P contents in the shoots and bulbs, however, significantly influenced the amount accumulated in the plant. Although the most productive cultivars extracted larger amount of N and P per area, they used less N and P for each ton of bulb produced. Despite the variation between cultivars in total content, the amount of N and P in the bulbs was not changed. This suggests that there is a control by the plant for the amount of these nutrients accumulated in the bulb, which was kept in balance with the shoot. This is also observed for Mg and K, which are also mobile nutrients in the plants.

N and P, respectively, were the second and third nutrients most required by onion, which was also reported by other authors (Pôrto *et al*., 2006; Vidigal *et al*., 2010) and other vegetable crops (Filgueira, 2003) .

K was the nutrient most accumulated in the shoots and bulbs of onion (Table 2) and the most extracted one (Table 3). However, the onion response to fertilization with K are generally limited (Magalhães, 1993), contrary to N (Brewster, 1994). Although being the nutrient most absorbed by onion, only about 18% was allocated to the bulbs (Table 3), which makes their content per bulb ton similar to N. This appears to contrast with the K function which, in species that accumulate organic compounds in the bulbs, has a role in the transport of solutes and consequently the expansion of cataphylls, influencing the growth and size of the bulbs (Mógor, 2000). Porto *et al.* (2006) and Vidigal *et al.* (2010) also found K to be the most accumulated nutrient in onion.

In general, the cultivar Alfa São Francisco-RT, with the highest bulb yield, showed the highest K, Ca and Mg content in the shoots, and BR 29, with the lowest bulb yield, had the lowest levels these nutrients, especially calcium and magnesium. The highest levels in the most productive cultivar indicate its greater demand for these nutrients. There was little genetic influence on the partition of macronutrients between shoot and bulb, whose contents was higher in the shoot, which is in agreement with other authors (Pôrto *et al*., 2006; Santos *et al*., 2009).

Nutrient content can be used to determine the amount of nutrient extracted and exported by the species. In the first case, one considers the nutrient present in the whole plant and an estimate of the nutrient requirement by the species is obtained. In the second case, one can use the information to tailor the fertilizer application according to the productivity of each crop. The most productive cultivars had the lowest nutrient content per bulb ton produced, which shows greater efficiency of these cultivars in using the nutrients absorbed.

The descending order of nutrient levels found in most cultivars for both shoot and bulbs, which was K > N > P > Ca > Mg, differs from other authors' reports. According to Santos *et al.* (2007), the cultivars IPA-10 and Alfa São Francisco showed the following order of levels in the shoots: N > Ca > K > Mg > P and N > Ca > K > P > Mg, respectively. On the other hand, May *et al.* (2008) reported nutrient levels as N > P > K > Ca > Mg for cultivars Optima and Superex. Vidigal *et al.* (2010) observed nutrient levels as K > N > Ca > P > Mg. These variations suggest influence mainly of the crop environment, since the differences among cultivars in the different studies was not significant. In this study, the organic farming techniques with planting in January - off the recommended time for the region – with harvest expected in August, may have influenced the results.

For micronutrient contents, there is no clear definition for differences among cultivars. Fe is the micronutrient with the highest content in all cultivars, which was also reported by Vidigal *et al.* (2010). Similar to Fe, B levels were

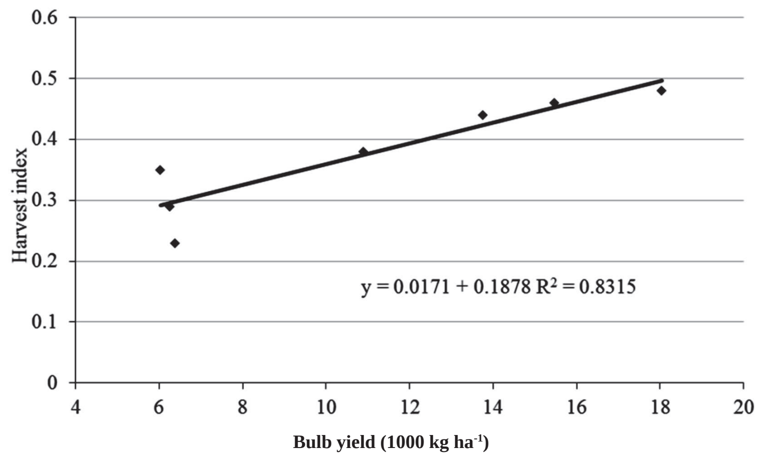

Figure 1: Relationship between bulb yield and harvest index (ratio between dry part of harvested bulb and total dry part of the plant - bulb + shoot) of onion cultivars in organic system ($R^2 < 0.01$).

Table 2: Nutrient contents in shoots and bulbs of onion cultivars at 99 days after transplantation, in organic system and early planting in the metropolitan region of Curitiba

Cultivar*	N		P		K		Ca		Mg	
	Shoot	Bulb	Shoot	Bulb	Shoot	Bulb	Shoot	Bulb	Shoot	Bulb
	g kg-1									
IPA-10	30.12 a	27.59 a	3.69 aA	4.24 aA	32.43 dA	25.27 cdB	3.63 abA	3.01 aB	2.34 abA	1.66 aB
IPA-11	29.73 a	27.02 a	4.11 aA	5.06 aA	35.78 bcdA	27.54 cB	3.10 bcA	2.34 bB	2.22 abcA	1.66 aB
PA-12	30.83 a	30.64 a	3.92 aA	4.61 aA	39.05 abcA	33.81 abB	3.42 bcA	2.86 aA	2.11 bcA	1.79 aB
A. Trop	27.15 a	22.36 a	4.19 aA	4.04 aA	34.86 bcdA	23.62 dB	3.34 abcA	2.37 bB	2.24 abcA	1.55 abB
ASF VIII	26.74 a	25.21 a	3.61 aA	4.08 aA	33.31 cdA	27.33 cB	3.06 bcA	1.60 cB	1.95 cA	1.51 abB
ASF –RT	30.08 a	31.29 a	3.67 aB	5.32 aA	42.01 aA	35.34 aB	4.14 aA	1.84 cB	2.52 aA	1.94 aB
BR-29	32.51 a	33.74 a	4.07 aA	4.63 aA	39.76 abA	31.35 bB	2.69 cA	1.50 cB	1.99 cA	1.20 bB
Mean	29.59	28.26	3.89	4.57	36.74	29.18	3.34	2.22	2.2	1.62
CV (%)	10.86	21.56	15.58	17.65	5.8	4.43	8.66	7.42	4.95	9.75

Cultivar*	Cu		Mn		Fe		Zn		B	
	Shoot	Bulb	Shoot	Bulb	Shoot	Bulb	Shoot	Bulb	Shoot	Bulb
	mg kg-1									
IPA-10	5.0 bB	8.5 bcA	9.6 eA	7.0 abcB	327.9 aB	542 aA	77.9 nsA	13.9 bcB	11.2 abB	77.9 aA
IPA-11	6.7 aA	6.8 cA	15.5 aA	9.5 aB	291.3 abB	571 aA	61.8 A	21.7 aB	14.0 aB	61.8 aA
PA-12	6.3 abB	9.2 abcA	11.2 cdeA	7.8 abB	265.3 abcB	524 aA	78.5 A	11.6 cB	11.3 abB	78.5 aA
A. Trop	5.2 bB	9.6 abA	11.6 bcdA	9.5 aA	226.3 bcB	561 aA	87.9 A	16.3 bB	10.8 abB	87.9 aA
ASF VIII	5.5 abB	7.1 bcA	13.0 bA	6.3 bcB	205.1 cB	265 bA	63.0 A	15.7 bcB	13.2 aB	63.0 aA
ASF –RT	6.2 abB	9.1 abcA	12.8 bcA	6.3 bcB	297.0 aA	218 bB	69.9 A	16.2 bB	13.2 aB	69.9 aA
BR-29	6.5 abB	11.0 aA	10.4 deA	4.7 cB	197.5 cA	162 bB	75.3 A	13.4 bcB	7.2 bB	75.3 aA
Mean	5.9	8.8	12	7.3	258.6	406.1	73.5	15.6	11.6	73.5
CV (%)**	9.16	10.26	5.31	12.16	9.56	9.62	19.62	10.15	14.76	19.62

*Cultivar: IPA-10=Franciscana IPA-10; IPA-11=Vale Ouro IPA-11; IPA-12=Brisa IPA-12, A. Trop=Alfa Tropical; ASF VIII=Alfa São Francisco – Ciclo VIII; ASF-RT=Alfa São Francisco – RT and; BR-29= BR-29. ** Coefficient of Variation (CV%). Means followed by the same small letter in the columns are not significantly different by the Tukey test at 5% probability. Means followed by the same capital letter in the rows are not significantly different by the F test. Absence of capital letters indicates that there was no significant difference.

higher in bulbs compared to shoot, also agreeing with the findings of Vidigal *et al*. (2000).

The highest concentration of Cu in the bulb observed in most cultivars, except for IPA-11 and Alfa São Francisco. Cu, besides a constituent of several enzymes involved in the processes of photosynthesis, respiration, hormone regulation, N fixing and secondary compound metabolism, also affects the bulb skin color, by intensifying it, and provides increased peel strength and less weight loss during storage (Mendes *et al*., 2008). The higher Mn content in shoots of onion in relation to bulbs agree with the results reported by Vidigal *et al*. (2003), but the same behavior observed for Zn was not found by Vidigal *et al*. (2000), whose results showed a higher concentration of this nutrient in bulbs.

The order of micronutrient levels in the shoot Fe > Zn > Mn = B > Cu in all cultivars differs from that obtained by Vidigal *et al*. (2010), in which the most absorbed micronutrients by onion were Fe and Mn, being followed by Cu and Zn; B was not evaluated.

Fe, followed by Zn and B, is the most absorbed micronutrient by onion, also present in greater quantities in the bulbs (Table 3). Proportionally, Zn is the most exported nutrient with bulb harvest (68% of the total absorbed), which should be considered in fertilizer replacement of this nutrient, especially in successive crops of onion.

CONCLUSIONS

The most productive cultivars for off-season planting in organic system in the metropolitan region of Curitiba were Alfa São Francisco-RT, Alfa São Francisco and Alfa Tropical.

Yield of onion bulbs has no relation to yield of shoots.

Macronutrient contents in both onion shoots and bulbs was in the following order: K > N > P > Ca > Mg.

Fe was the most absorbed micronutrient by onion, followed by Zn > B > Mn > Cu.

The amount of nutrients accumulated in the shoots was higher than in bulbs, and the most productive cultivars were the most efficient ones, since they provided greater bulb yield per each kg of nutrient extracted.

Table 3: Extraction (shoot + bulb) and export (bulb) of nutrients per ton of fresh bulb produced by onion cultivars in organic system and early planting in southern Brazil

Cultivar*	N	P	K	Ca	Mg	Cu	Mn	Fe	Zn	B
			kg					g		
Extration (shoot + bulb)										
IPA-10	6.60 bc	0.88 bc	6.77 bc	0.77 a	0.48 a	1.39 ab	2.00 bc	88.71 a	9.25 a	2.96 ab
IPA-11	5.49 bcd	0.85 bc	6.23 bc	0.54 bc	0.38 b	1.29 ab	2.50 ab	76.57 a	7.13 bcd	3.60 a
PA-12	7.65 ab	1.02 ab	9.37 Ab	0.83 a	0.51 a	1.81 ab	2.49 ab	85.23 a	9.44 a	2.97 ab
A. Trop	4.50 cd	0.74 bc	5.39 C	0.52 bc	0.35 bc	1.28 ab	1.92 c	66.26 ab	8.73 abc	2.53 ab
ASF VIII	4.30 cd	0.64 c	5.04 C	0.39 c	0.29 c	1.04 b	1.66 cd	39.46 b	6.91 cd	2.46 ab
ASF –RT	4.01 d	0.58 c	5.08 C	0.40 c	0.29 c	1.00 b	1.28 d	34.26 b	5.66 d	1.94 b
BR-29	9.74 a	1.25 a	11.27 A	0.72 ab	0.54 a	2.23 a	2.70 a	56.61 ab	8.90 ab	3.55 a
Mean	6.04	0.85	7.02	0.60	0.40	1.44	2.08	63.87	8.00	2.86
CV (%)	14.58	15.19	16.74	12.58	5.73	25.11	8.70	19.30	8.71	19.54
Export (bulb)										
IPA-10	2.16 ns	0.33 ns	1.98 ns	0.23 a	0.13 ns	0.66 ab	0.55 bc	42.05 a	6.06 ab	0.88 ab
IPA-11	2.00	0.38	2.03	0.17 ab	0.12	0.50 c	0.71 a	42.05 a	4.59 b	1.04 ab
PA-12	2.21	0.34	2.46	0.21 ab	0.13	0.69 ab	0.58 ab	38.47 ab	5.68 ab	0.80 b
A. Trop	1.74	0.31	1.84	0.18 ab	0.12	0.76 a	0.73 a	43.18 a	6.86 a	0.86 ab
ASF VIII	1.93	0.32	2.08	0.12 ab	0.12	0.55 bc	0.50 bc	21.09 ab	4.96 ab	1.06 a
ASF –RT	1.99	0.34	2.24	0.12 ab	0.12	0.58 bc	0.41 cd	13.90 b	4.42 b	0.84 ab
BR-29	2.30	0.32	2.15	0.11 b	0.08	0.75 a	0.32 d	11.23 b	5.10 ab	0.49 c
Mean	2.05	0.33	2.11	0.16	0.12	0.64	0.54	30.28	5.38	0.85
CV (%)**	22.59	21.88	18.89	27.85	17.92	7.99	10.64	33.02	13.91	9.83

*Cultivar: IPA-10=Franciscana IPA-10; IPA-11=Vale Ouro IPA-11; IPA-12=Brisa IPA-12, A. Trop=Alfa Tropical; ASF VIII=Alfa São Francisco – Ciclo VIII; ASF-RT=Alfa São Francisco – RT (thrips resistant) e; BR-29= BR-29. ** Coefficient of Variation (CV%). Means followed by the same letter are not statistically different by the Tukey test at 5% probability.

REFERENCES

Alloway BJ (2004) Zinc in soils and crop nutrition. Disponível em: <http://www.zincworld.org>. Acessado em: 15 de setembro de 2013.

Bataglia OC, Furlani AMC, Teixeira JPF, Furlani PR & Gallo JR (1983) Métodos de análise química de plantas. Campinas, Instituto Agronômico. 48p.

Bettoni MM, Mógor AF, Pauletti V, Da Silva VCP, Koyama R & Peñuela LYF (2012) Agronomic performance of cultivars of organic onion in two harvest times. Idesia, 30:11-18.

Boeing G (2002) Fatores que afetam a qualidade da cebola na agricultura familiar catarinense. Florianópolis, Instituto Cepa. 88p.

Brewster JL (1994) Onions and Other Vegetable Alliums. Wallingford, CAB International. 432p.

Buzar AGR,Oliveira VR & Boiteux LS (2007) Estimativa da diversidade genética de germoplasma de cebola via descritores morfológicos, agronômicos e bioquímicos. Horticultura Brasileira, 25:527-532.

CEPA - Centro de Socioeconomia e Planejamento Agrícola (2012) Informativos agropecuários. Disponível em: <http://cepa.epagri.sc.gov.br>. Acessado em: 18 de dezembro de 2013.

Filgueira FAR (2003) Novo manual de olericultura: agrotecnologia moderna na produção e comercialização de hortaliças. 2ª ed. Viçosa, UFV. 402p.

IBGE - Instituto Brasileiro de Geografia e Estatística (2012) Produção Agrícola Municipal. Disponível em: <http://www.sidra.ibge.gov.br>. Acessado em: 20 de maio de 2013.

Magalhães JR (1993) Nutrição e adubação da Cebola. In: Ferreira ME, Castellane PD & Cruz MCP (Eds.) Nutrição e adubação de hortaliças. Piracicaba, Potafós. p.381-393.

Martins APL & Reissmann CB (2007) Material vegetal e as rotinas laboratoriais nos procedimentos químico-analíticos. Scientia Agrária, 8:01-17.

May A, Cecílio Filho AB, Porto DRQ, Vargas PF & Barbosa JC (2008) Acúmulo de macronutrientes por duas cultivares de cebola produzidas em sistema de semeadura direta. Bragantia, 67:507-512.

Melo PCT & Ribeiro A (1990) Produção de sementes de cebola: cultivares de polinização aberta e híbridos. In: Castellane PD, Nicolosi WM & Hasegawa M (Eds.) Produção de sementes de hortaliças. Jaboticabal, FCAV/FUNESP. p.15-59.

Mendes AMS, Silva DJ, Faria CMB de, Resende GM, Oliveira Neto MB & Silva MSL da (2008) Nutrição Mineral e Adubação da Cultura da Cebola no Submédio do Vale do São Francisco. Petrolina, Embrapa Semiárido. 10p. (Circular técnica, 86).

Mendonça JL, Madeira NR & Resende FV (2004) Sistema de produção de cebola. Disponível em: <http://www.cnph.embrapa.br/sistprod/cebola/plantio.htm.>. Acessado em: 15 de março de 2013.

Michigan development team (1989) MSTAT-C: Microcomputer Statistical Program. Version 2.1. Michigan, Michigan State University. CD-ROM.

Mógor AF (2000) Nível nutricional e incidência de doenças foliares na cultura da cebola (*Allium cepa* L.). Dissertação de Mestrado. Universidade Estadual Paulista “Julio de Mesquita Filho”, Botucatu. 65p.

Pôrto DRQ, Cecílio Filho AB, May A & Barbosa JC (2006) Acúmulo de macronutrientes pela cultivar de cebola “Optima” estabelecida por semeadura direta. Horticultura Brasileira, 24:470-475.

Raij BV, Silva NM, Bataglia OC, Quaggio JÁ, Hiroce R, Cantarella H, Bellizazzi Júnior R, Dechen AR & Trani PE (1996) Recomendações de adubação e calagem para o Estado de São Paulo. 2ª ed. Campinas, Instituto Agronômico. 70p. (Boletim Técnico, 100).

Santos EEF, Fernandes DM, Silva DJ & Bull LT (2007) Acúmulo de macronutrientes por cultivares de cebola, em um Vertissolo no médio São Francisco. In: 31º Congresso Brasileiro de Ciência do Solo, Porto Alegre. Anais, Sociedade Brasileira de Ciência do Solo. CD-ROM.

Santos EEF, Fernandes DM, Silva DJ & Santo MHLC (2009) Acúmulo de macronutrientes pela cebola “Alfa São Francisco” em um Argissolo no Submédio São Francisco. In: 32º Congresso Brasileiro de Ciência do Solo, Fortaleza. Anais, Universidade Federal do Ceará / Sociedade Brasileira de Ciência do Solo. CD-ROM.

SEAB/DERAL - Secretaria da Agricultura e do Abastecimento / Departamento de Economia Rural (2009) Valor bruto da agropecuária paranaense. Disponível em: <http://www.pr.gov.br/seab/deral>. Acessado em: 15 de fevereiro de 2013.

Simepar - Instituto Tecnológico Simepar (2010) Temperatura média, precipitação mensal, fotoperíodo e umidade relativa – Pinhais / Curitiba. (Documento não publicado. Obtido por solicitação em 10/09/2010).

Vidigal SM, Pereira PRG, Sediyama CS, Sediyama MAN & Fontes PCR (2000) Produção de cebola influenciada por doses, fontes e parcelamento de nitrogênio em diferentes épocas de cultivo no verão. Horticultura Brasileira, 18:814-815.

Vidigal SM, Pereira PRG, Pacheco DD & Facion CE (2003) Absorção de micronutrientes pela cultura da cebola. Horticultura Brasileira, 21:374-374.

Vidigal SM, Moreira MA & Pereira PRG (2010) Crescimento e absorção de nutrientes pela planta cebola cultivada no verão por semeadura direta e por transplantio de mudas. Bioscience Journal, 26:59-70.