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THE EFFECT OF POLIMAG S FERTILIZER ON THE MACRONUTRIENT CONTENT OF THE EDIBLE PARTS OF THREE WELSH ONION (*ALLIUM FISTULOSUM* L.) CULTIVARS

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Abstract

Welsh onions are characterized by a relatively high storage potential, high nutritional value and mild flavor, which contribute to their growing popularity among consumers. The aim of this study was to determine the effect of Polimag S fertilizer applied at two doses on the macronutrient content of edible parts of three Welsh onion cultivars.

A two-factorial field experiment was performed in a randomized block design with three replications. It was set up in the Experimental Garden of the University of Warmia and Mazury in Olsztyn, and conducted in 2010-2011. The experimental factors were: (1) Welsh onion cultivars Long White Ishikura, Parade and Performer, grown from seedlings for bunch harvest, and (2) the application of mixed fertilizer, Polimag S, at two doses of 0.072 kg m^{-2} and 0.144 kg m^{-2}. The seedlings were grown in a greenhouse, where each year seeds were sown in boxes (50 cm x 30 cm), between 14 and 20 March, to grow seedlings. At the two- or three-leaf stage, they were planted out in a field between 17 and 26 April. Forty-two seedlings were planted on a plot, at the 20 cm x 30 cm spacing. Polimag S, applied as a supplemental fertilizer at two different doses, was mixed with soil immediately before the transplanting of seedlings. A single harvest was carried out manually. Marketable yield consisted of healthy Welsh onion plants, with thickened leaf-bases of more than 1 cm in diameter, free from diseases, pests and mechanical damage. The chemical composition of Welsh onion plants was evaluated immediately after harvest. The concentrations of macronutrients (total N, P, K, Mg, Ca, S) were determined in edible parts of Welsh onion plants.

Statistical analysis revealed no significant effect of a cultivar on the macronutrient content of whole Welsh onion plants, scapes and leaves. Leaves were characterized by the highest macronutrient concentrations. Polimag S at a 50% dose contributed to a significant increase in the total nitrogen and phosphorus content of whole plants. Wide Ca:Mg, Ca:P, K:Mg and K:(Mg+Ca) ratios were noted in whole Welsh onion plants.

Key words: Welsh onion, Polimag S, scapes, leaves, macronutrients.

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WPŁYW NAWOŻENIA POLIMAGIEM S NA ZAWARTOŚĆ MAKROELEMENTÓW W CZĘŚCIACH JADALNYCH TRZECH ODMIAN SIEDMIOLATKI (*ALLIUM FISTULOSUM* L.)

Abstrakt

Siedmiolatka charakteryzuje się dość dobrą trwałością pozbiorczą, dużą wartością dietetyczną oraz łagodnym smakiem, który wzbudza coraz większe zainteresowanie konsumentów warzyw. Celem badań była ocena zawartości makroelementów w częściach jadalnych 3 odmian siedmiolatki nawożonej zróżnicowanymi dawkami Polimagu S.

W latach 2010-2011 – w Ogrodzie Zakładu Dydaktyczno-Doświadczalnego Uniwersytetu Warmińsko-Mazurskiego w Olsztynie – przeprowadzono 2-czynnikowe doświadczenie polowe w układzie losowanych bloków, w 3 powtórzeniach. Badano wpływ następujących czynników: odmiany siedmiolatki Long White Iskihura, Parade, Performer przeznaczonej na zbiór pęczkowy oraz nawożenie nawozem wieloskładnikowym Polimag S w dwóch dawkach – 0,072 kg m^{-2} i 0,144 kg m^{-2}. Siedmiolatkę uprawiano z rozsady. Każdego roku, między 14. a 20, marca nasiona wysiewano w szklarni-mnożarce do skrzynek wysiewnych o wym. 50x30 cm. W kolejnych latach rośliny w fazie 2-3 liści sadzono pojedynczo na polu między 17. a 26. kwietnia. Na poletku sadzono 42 rośliny w rozstawie 20x30 cm. Uzupełniające nawożenie Polimagiem S w dwóch zróżnicowanych dawkach zastosowano mieszając nawóz z glebą bezpośrednio przed sadzeniem rozsady. Zbiór roślin wykonywano jednorazowo, ręcznie. Do plonu handlowego zaliczano rośliny o średnicy cebuli powyżej 1 cm, zdrowe, nieporażone przez choroby i szkodniki, bez uszkodzeń mechanicznych. Ocenę składu chemicznego siedmiolatki wykonano bezpośrednio po zbiorze. W częściach jadalnych określono zawartość makroelementów (N ogólny, P, K, Mg, Ca, S).

Analiza statystyczna nie wykazała istotnego wpływu odmiany na zawartość badanych składników w całej roślinie, łodydze rzekomej oraz liściach asymilacyjnych. Analizując zawartość makroelementów w poszczególnych częściach jadalnych siedmiolatki wykazano, że najbardziej zasobne w te pierwiastki były liście asymilacyjne. Zastosowanie 50% nawożenia uzupełniającego Polimagiem S wpłynęło istotnie na zwiększenie zawartości N ogólnego i P w całych roślinach. W całych roślinach siedmiolatki stwierdzono zwiększone proporcje między Ca:Mg, Ca:P oraz K:Mg i K:(Mg+Ca).

Słowa kluczowe: siedmiolatka, Polimag S, łodyga rzekoma, szczypior, makroelementy.

INTRODUCTION

Welsh onion (*Allium fistulosum* L.) in Poland is grown on a small scale. In contrast, it is popular and widely used in the Far East. Owing to their mild, sweet flavor and delicate consistency, whole Welsh onion plants are used as ingredients in various dishes. Recent years have witnessed a growing popularity of Welsh onions in the Polish cuisine, particularly in the spring (Rabinowitch, Brewster 1990, Tendaj, Mysiak 2006, Żurawik et al. 2013).

The yield and quality of Welsh onions are depend on a cultivar and an adequate supply of nutrients. Mineral fertilizers are widely used in horticultural farming. Advanced fertilization programs rely on compound fertilizers which meet the specific nutrient requirements of different crop species. Bulbous vegetables should be fertilized in the spring with Polimag S, the next generation mixed fertilizer that contains sulphur trioxide, because this chem-

ical compound is recommended to plants sensitive to chloride excess. Polimag S can be mixed with urea, ammonium nitrate and nitrochalk immediately before sowing, and with potassium sulphate at any time before application (Filipek-Mazur, Gondek 2005).

The aim of this study was to determine the effect of cultivar and Polimag S fertilizer applied at different rates on the macronutrient content of whole Welsh onion plants, scapes and leaves.

MATERIAL AND METHODS

In 2010-20122, a two-factorial field experiment was performed in a randomized block design with three replications in the Experimental Garden of the University of Warmia and Mazury in Olsztyn. The effects of the following experimental factors were determined:

- Welsh onion cultivars Long White Ishikura, Parade and Performer grown from seedlings for bunch harvest;
- application of mixed fertilizer Polimag S, at two doses of 0.072 kg m^{-2} and 0.144 kg m^{-2}, referred to as 50% and 100% doses. Polimag S contained 10% N, 8% P, 15% K and 35% S.

Seedlings were grown in a greenhouse, where onion seed had been sown (2 g m^{-2}) in boxes (50 cm x 30 cm), each year between 14 and 20 March. The seedlings were prepared in line with the bulbous vegetable planting guidelines (*Rozsada warzyw…* BN-88/9125-08). The substrate used for seedling production was highmoor peat saturated with minerals and nutrients: $N\text{-}NO_3$ – 100, P – 80, K – 215, Ca – 1240, Mg – 121 g dm^{-3}, pH in H_2O – 5.9, salt concentration – 1.5 g dm^{-3}.

In order to develop a fertilization program, chemical analyses of soil samples were performed at the Chemical and Agricultural Station in Olsztyn, under Accreditation Certificate no. AB 277 issued by the Polish Center for Accreditation in Warsaw. The soil in which Welsh onion seedlings were planted was found to be abundant in phosphorus and potassium, and no supplemental fertilization with those elements was needed throughout the experiment. Due to the low nitrate nitrogen content of soil, nitrogen was applied at a single dose of 30 kg ha^{-1} in the form of ammonium nitrate, before transplanting the seedlings.

Seedlings at the two- or three-leaf stage were individually planted out in the field between 17 and 26 April. Forty-two seedlings were planted at the 20 cm x 30 cm spacing. The surface area of the plot was 2.52 m^2. Polimag S, applied as a supplemental fertilizer at two different doses, was mixed with the soil immediately before transplanting the seedlings.

A single harvest was carried out by hand. Marketable yield consisted of healthy Welsh onion plants, with thickened leaf-bases of more than 1 cm in diameter, free from diseases, pests and mechanical damage.

The chemical composition of Welsh onion plants was evaluated immediately after harvest. Plant material was collected from the marketable yield in each replication, to obtain an average sample per treatment. The concentrations of macronutrients (total N, P, K, Mg, Ca, S) were determined in edible parts of Welsh onion plants. The results were highly similar in both years of the study, hence the data are given as means from 2010-2011 for whole plants, scapes and leaves. Samples of plant material were prepared for analysis as follows: whole Welsh onion plants were cleaned, divided into scapes and leaves, which were dried at 45°C and 35°C respectively, and ground in an electric mill. The samples were forwarded to the laboratory at the Chemical and Agricultural Station in Olsztyn, where they were mineralized in concentrated sulphuric acid to determine the content of total nitrogen – by potentiometry, phosphorus – by the vanadium-molybdate method, potassium and sodium – by flame photometry, magnesium – by atomic absorption spectrometry (AAS), calcium – by flame photometry.

The significance of differences between means was estimated by constructing the Tukey's confidence intervals at a 5% significance level. All calculations were done in the Statistica 10 application.

RESULTS AND DISCUSSION

Welsh onions are characterized by a relatively high storage potential, high nutritional value and mild flavor, which contribute to their growing popularity among consumers. (Franczuk 2000, Tendaj, Mysiak 2006, Tendaj, Mysiak 2007, Żurawik et al. 2013). Minerals aid in maintaining the body's acid-base balance and contribute to the health and strength of the skeletal system (Filipek-Mazur, Gondek 2005). The levels of the analyzed macronutrients in Welsh onion plants were similar to those reported for the leek by Biesiada et al. (2007) and for the onion by Błażewicz-Woźniak et al. (2008). In the present study, a cultivar had no significant effect on the macronutrient concentrations in edible parts of Welsh onion plants, whereas the supplemental fertilization with Polimag S affected the levels of total nitrogen and phosphorus. Jurgiel-Małecka and Suchorska-Orłowska (2008) noted similar macroelement concentrations in edible parts of common onions, tree onions and shallots at different levels of nitrogen fertilizer.

The total nitrogen content in whole Welsh onion plants ranged from 11.90 g kg^{-1} d.m. to 25.00 g kg^{-1} d.m., and was significantly affected by the dose of Polimag S and the fertilizer x cultivar interaction (Table 1). The above values are similar to those reported for Welsh onions by Kołota et al. (2012), and lower than those noted in a study on tree onions (Orłowski, Jadczak 2003). An increase in the total nitrogen content was observed in whole Welsh onion plants harvested from plots fertilized with Polimag S at 50% dosage. Welsh onions cv. Long White Ishikura from the treatment with

Table 1

Total nitrogen content in edible parts of Welsh onion plants, subject to cultivar and Polimag S dose (means of 2010-2011), g kg^{-1} d.m.

Fertilization*	Cultivar			
	Long White Ishikura	Parade	Performer	mean
Whole plants				
Control	12.80	14.60	11.90	13.10
50%	25.00	19.90	14.40	19.80
100%	12.70	12.70	18.00	14.50
Mean	16.80	15.70	14.80	15.80
$LSD_{0.05}$ for: cultivar fertilizer interaction	n.s. 0.300 0.400			
Scapes				
Control	11.00	12.00	8.000	10.00
50%	21.00	24.00	8.000	18.00
100%	9.000	10.00	13.00	11.00
Mean	14.00	15.00	9.000	13.00
$LSD_{0.05}$ for: cultivar fertilizer interaction	n.s. 0.500 0.600			
Leaves				
Control	14.40	17.10	15.60	15.70
50%	28.80	15.60	20.60	21.60
100%	16.50	15.30	22.40	18.00
Mean	19.90	16.00	19.50	18.40
$LSD_{0.05}$ for: cultivar fertilizer interaction	n.s. n.s. n.s.			

* Key: control – treatment that received no fertilizer, 50% – treatment that received 0.072 kg m^{-2} Polimag S, 100% – treatment that received 0.144 kg m^{-2} Polimag S

Polimag S at 50% had the highest total nitrogen content, and control plants had the lowest nitrogen concentration (a significant difference). An analysis of the fertilizer x cultivar interaction revealed that plants of cv. Performer from the control treatment had the lowest total nitrogen content.

Fertilization and the interaction between the experimental factors had a significant effect on the total nitrogen content of Welsh onion scapes, which

ranged from 8.00 g kg^{-1} d.m. to 24.00 g kg^{-1} d.m. The scapes of cv. Parade from the treatment with Polimag S at a 50% dose had the highest total nitrogen content, whereas the lowest nitrogen concentrations were noted in the scapes of cv. Performer from the control treatment and from the treatment with Polimag S at a 50% dose (significant differences). A similar nitrogen content was observed in the scapes of cv. Long White Ishikura fertilized with Polimag S at a 100% dose.

Welsh onion leaves contained more total nitrogen than scapes (18.40 g kg^{-1} d.m. vs. 13.00 g kg^{-1} d.m. on average, means of 2010-2011). The total nitrogen content of leaves ranged from 14.40 g kg^{-1} d.m. to 28.80 g kg^{-1} d.m., and it was similar to that reported by Orłowski and Jadczak (2003) in tree onion leaves. The leaves of cv. Long White Ishikura from the treatment with Polimag S at a 50% dose and from the control treatment had the highest and the lowest total nitrogen content, respectively (a non-significant difference).

The cultivar had no effect on the phosphorus content of whole Welsh onion plants (Table 2), which was significantly affected by the doses of Polimag S and the fertilizer x cultivar interaction. Polimag S contributed to an increase in phosphorus concentrations in Welsh onions, which werethe highest in plants harvested from plots fertilized with Polimag S at a 50% dose. The experimental factors and their interaction had no significant effect on the phosphorus accumulation in Welsh onion scapes and leaves, which reached 2.000 g kg^{-1} d.m. and 3.000 g kg^{-1} d.m. on average, respectively (means of 2010-2011). Similar results were reported by Kołota et al. (2012).

The potassium content of whole Welsh onion plants was not significantly affected by the experimental factors. The fertilizer x cultivar interaction had a significant effect on potassium concentrations, which ranged from 13.40 g kg^{-1} d.m. in control plants of cv. Performer to 18.80 g kg^{-1} d.m. in control plants of cv. Parade (Table 3). The observed values are lower than those reported by Kołota et al. (2012) for Welsh onions grown in the Wrocław region. The potassium content in edible parts of Welsh onions was not significantly influenced by a cultivar, fertilizer or their interaction. Welsh onion leaves contained more potassium than scapes (19.00 g kg^{-1} d.m. vs. 13.00 g kg^{-1} d.m. on average, means of 2010-2011).

Differences in the levels of magnesium, calcium and sulphur in Welsh onions were statistically non-significant (Tables 4, 5 and 6). Average magnesium concentrations were as follows: whole plants – 1.000 g kg^{-1} d.m., scapes – 0.900 g kg^{-1} d.m., leaves – 1.100 g kg^{-1} d.m.. The respective average calcium levels were 11.40 g kg^{-1} d.m., 10.30 g kg^{-1} d.m. and 12.30 g kg^{-1} d.m.

Sulphur is a component of volatile compounds such as aliphatic triesters, polysulfides and sulfoxides. Allium vegetables, including onions and garlic, are high in beneficial *sulphur* compounds that give them their distinctive *flavor* and aroma. Sulphur prevents excess accumulation of nitrates (V) and reducing sugars, thus increasing the quality and processing suitability of those vegetables (El-Fayoumy, El-Gamal 1998). The average sulphur content

Table 2

Phosphorus content in edible parts of Welsh onion plants, subject to cultivar and Polimag S dose (means of 2010-2011), g kg^{-1} d.m.

Fertilization*	Cultivar			
	Long White Iskihura	Parade	Performer	mean
Whole plants				
Control	2.800	2.600	2.700	2.700
50%	3.600	3.800	3.700	3.700
100%	2.500	2.500	2.500	2.500
Mean	3.000	3.000	3.000	3.000
$LSD_{0.05}$ for: cultivar fertilizer interaction	n.s. 0.1 0.1			
Scapes				
Control	2.000	3.000	2.000	2.000
50%	3.000	4.000	2.000	3.000
100%	2.000	2.000	3.000	2.000
Mean	2.000	3.000	2.000	2.000
$LSD_{0.05}$ for: cultivar fertilizer interaction	n.s. n.s. n.s.			
Leaves				
Control	3.000	3.400	2.800	3.000
50%	4.000	2.800	3.000	3.200
100%	2.800	2.600	3.000	2.800
Mean	3.200	2.900	2.900	3.000
$LSD_{0.05}$ for: cultivar fertilizer interaction	n.s. n.s. n.s.			

* Key: see Table 1

of whole Welsh onion plants, scapes and leaves reached 2.300 g kg^{-1} d.m., 1.700 g kg^{-1} d.m. and 2.700 g kg^{-1} d.m., respectively.

According to Kotowska and Wybieralski (1999), the quality of edible plant parts is largely determined by the K:Mg, Ca:Mg and K:(Mg+Ca) ratios. Wróbel and Marska (1998) and Majkowska-Gadomska and Wierzbicka (2008) demonstrated that the optimal Ca:Mg ratio should approximate 3, and the Ca:P ratio should be within the 1.200-2.200 range because higher ratios are indicative of nutritional magnesium or phosphorus deficiency. In the present

Table 3

Potassium content in edible parts of Welsh onion plants, subject to cultivar and Polimag S dose (means of 2010-2011), g kg^{-1} d.m.

Fertilization*	Cultivar			
	Long White Iskihura	Parade	Performer	mean
Whole plants				
Control	15.80	18.80	13.40	16.00
50%	18.10	17.70	16.10	17.30
100%	15.70	14.70	16.60	15.70
Mean	16.50	17.10	15.40	16.30
$LSD_{0.05}$ for: cultivar fertilizer interaction	n.s. n.s. 0.02			
Scapes				
Control	13.00	16.00	10.00	13.00
50%	18.00	19.00	11.00	16.00
100%	11.00	11.00	13.00	12.00
Mean	14.00	15.00	11.00	13.00
$LSD_{0.05}$ for: cultivar fertilizer interaction	n.s. n.s. n.s.			
Leaves				
Control	18.30	21.90	16.80	19.00
50%	18.30	16.80	20.90	18.60
100%	19.90	18.30	20.60	19.60
Mean	18.80	19.00	19.40	19.00
$LSD_{0.05}$ for: cultivar fertilizer interaction	n.s. n.s. n.s.			

* Key: see Table 1

Table 4

Magnesium content in edible parts of Welsh onion plants, subject to cultivar and Polimag S dose (means of 2010-2011), g kg^{-1} d.m.

Fertilization*	Cultivar			
	Long White Iskihura	Parade	Performer	mean
Whole plants				
Control	1.000	1.000	0.900	1.000
50%	1.300	1.200	1.000	1.200
100%	0.700	0.800	1.200	0.900
Mean	1.000	1.000	1.000	1.000
$LSD_{0.05}$ for: cultivar fertilizer interaction	n.s. n.s. n.s.			
Scapes				
Control	1.000	0.900	0.700	0.800
50%	1.300	1.300	0.700	1.100
100%	0.700	0.700	1.100	0.800
Mean	1.000	1.000	0.800	0.900
$LSD_{0.05}$ for: cultivar fertilizer interaction	n.s. n.s. n.s.			
Leaves				
Control	1.100	1.200	1.100	1.100
50%	1.400	1.100	1.300	1.200
100%	0.800	1.000	1.300	1.000
Mean	1.100	1.100	1.200	1.100
$LSD_{0.05}$ for: cultivar fertilizer interaction	n.s. n.s. n.s.			

*Key: see Table 1

Table 5

Calcium content in edible parts of Welsh onion plants, subject to cultivar and Polimag S dose (means of 2010-2011), g kg^{-1} d.m.

Fertilization*	Cultivar			
	Long White Iskihura	Parade	Performer	mean
Whole plants				
Control	12.50	10.70	11.30	11.50
50%	12.00	11.70	14.10	12.60
100%	9.400	10.30	10.70	10.10
Mean	11.30	10.90	12.00	11.40
$LSD_{0.05}$ for: cultivar fertilizer interaction	n.s. n.s. n.s.			
Scapes				
Control	15.00	10.00	8.200	11.00
50%	15.80	9.000	12.80	12.50
100%	8.400	8.700	5.600	7.500
Mean	13.00	9.200	8.800	10.30
$LSD_{0.05}$ for: cultivar fertilizer interaction	n.s. n.s. n.s.			
Leaves				
Control	10.00	11.40	14.30	11.90
50%	8.100	14.30	15.30	12.50
100%	10.40	11.80	15.70	12.60
Mean	9.500	12.50	15.10	12.30
$LSD_{0.05}$ for: cultivar fertilizer interaction	n.s. n.s. n.s.			

* Key: see Table 1

Table 6

Sulfur content in edible parts of Welsh onion plants, subject to cultivar and Polimag S dose (means of 2010-2011), g kg^{-1} d.m.

Fertilization*	Cultiver			
	Long White Iskihura	Parade	Performer	mean
Whole plants				
Control	1.900	2.400	2.200	2.200
50%	2.400	2.800	2.400	2.500
100%	2.000	2.000	2.400	2.100
Mean	2.100	2.400	2.300	2.300
$LSD_{0.05}$ for: cultivar fertilizer interaction	n.s. n.s. n.s.			
Scapes				
Control	1.700	1.900	1.700	1.800
50%	1.700	1.800	1.700	1.700
100%	1.600	1.900	1.700	1.700
Mean	1.700	1.900	1.700	1.700
$LSD_{0.05}$ for: cultivar fertilizer interaction	n.s. n.s. n.s.			
Leaves				
Control	2.000	2.800	2.600	2.500
50%	3.100	3.700	3.000	3.300
100%	2.300	2.100	3.100	2.500
Mean	2.500	2.800	2.900	2.700
$LSD_{0.05}$ for: cultivar fertilizer interaction	n.s. n.s. n.s.			

*Key: see Table 1

Table 7

Ca:Mg, Ca:P, K:Mg and K: (Mg+Ca) ratios in Welsh onion plants, subject to cultivar and Polimag S dose (means of 2010-2011)

Fertilization*	Cultivar			
	Long White Iskihura	Parade	Performer	mean
Ca:Mg				
Control	12.50	10.70	12.60	11.50
50%	9.200	9.800	14.10	10.50
100%	13.40	12.90	8.900	11.20
Mean	11.30	10.90	11.80	11.40
Ca:P				
Control	4.500	4.100	4.200	4.300
50%	3.300	3.100	3.800	3.400
100%	3.800	4.100	4.300	4.000
Mean	3.800	3.600	4.000	3.800
K:Mg				
Control	15.80	18.80	14.90	16.00
50%	13.90	14.80	16.10	14.40
100%	22.40	18.40	13.80	17.40
Mean	16.50	17.10	15.40	16.30
K:(Mg+Ca)				
Control	1.200	1.600	1.100	1.300
50%	1.400	1.400	1.100	1.300
100%	1.600	1.300	1.400	1.400
Mean	1.300	1.400	1.200	1.300

*Key: see Table 1

study, the Ca:Mg and Ca:P ratios were inadequate, and ranged from 8.90 to 14.10 and from 3.100 to 4.500, respectively (Table 7).

Wide K:Mg and K:(Mg+Ca) ratios were noted in edible parts of Welsh onion plants. According to Radkowski et al. (1999), optimal K:Mg and K:(Mg+Ca) ratios are 6:1 and 1.600-2.200, respectively. The highest K:Mg ratio was noted in the whole plants of cv. Long White Ishikura, and the lowest was in the leaves of cv. Performer, both fertilized with Polimag S at a 100% dose. The K:(Mg+Ca) ratio was in the 1.100-1.600 range. Polimag S at a 100% dose increased the K:Mg and K(Mg+Ca) ratios (Table 7). Our results are consistent with the findings of Wilk and Rabikowska (1985), and Kulczycki (2006).

CONCLUSIONS

1. Our statistical analysis revealed no significant effect of a cultivar on the macronutrient content of whole Welsh onion plants, scapes and leaves.

2. The analysis of macronutrient levels in whole Welsh onion plants, scapes and leaves showed that leaves were characterized by the highest macronutrient concentrations.

3. Polimag S at a 50% dose contributed to a significant increase in the total nitrogen and phosphorus content of whole plants.

4. Wide Ca:Mg, Ca:P, K:Mg and K:(Mg+Ca) ratios were noted in whole Welsh onion plants.

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