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EFFECT OF NITROGEN FERTILISATION ON THE MARKETABLE YIELD AND NUTRITIVE VALUE OF ONION

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ABSTRACT

The nutritive compounds of the onion are influenced by genetic as well environmental factors. Due to its shallow poorly-developed root system, onion has a low potential of using nutrients from soil. Usually mineral fertilisation increasing the yield and change the chemical composition in vegetables, and it is the chemical composition which determines the nutritive value of onion. Over 2003–2006 at Korytowo, about 30 km away from Bydgoszcz, northwards, 2-factor field experiments were set up in 'split-plot', in three reps. The aim of the study has been to determine the effect of the nitrogen rate (0, 60, 120, 180 kg N·ha^{-1}) on the content of dry matter, vitamin C and monosaccharides and total sugar in onion of two cultivars: Kutnowska and Efekt. Increasing nitrogen fertilisation has resulted in a decrease in the content of dry matter in the bulbs of the onions under study. The 'Kutnowska' showed a higher content of total sugar and, at the same time, a lower content of monosaccharides than 'Efekt'. 'Efekt' reacted with an increase in the content of vitamin C and monosaccharides as affected by higher fertilisation rates. A different reaction was noted in 'Kutnowska'. The lower the dry matter content in onion bulbs – the greater content of total sugars and less content of monosaccharides.

Key words: *Allium cepa*, dry matter, fertilisation, monosaccharides, total sugar, vitamin C

INTRODUCTION

Onion (*Allium cepa* L.) represents bulb vegetables, representing the genus Allium, the family Amaryllidaceae. According to the guidelines of dieticians, every day one should consume about 400 g of vegetables, including onion [Jarosz and Respondek 2010]. For a long time people have known its medicinal properties, e.g. inhibiting the development of pathogenic bacteria and fungi. Onion has a soothing effect on the nervous system, it triggers the production of gastric acids, as well as demonstrates diuretic properties. It also affects the human body as a deacidifier since it contains many alkaline substances [Sêdo and Krejĉa 1988]. Due to its composition, onion shows many health-enhancing properties; it is the source of vitamins A, B, C, E, K, sugar, organic acids, essential oils and mineral compounds with a high content of silicon bonds as well as antioxidants. One of more precious antioxidants is quercetin, which prevents heart diseases and neoplasms [Strzelecka and Kowalski 2000]. As a source of antioxidants in the human

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ration, it can protect the human body from the effect of free radicals, responsible not only for body ageing but also for cardiovascular and neurological diseases and other dysfunctions related to oxidative stress [Osmont et al. 2003, Dini et al. 2008, Gökçe et al. 2010, Pérez-Gregorio et al. 2010, Vidyavati et al. 2010]. Fructans found in onion, representing prebiotics, stimulate growth of microflora (*Lactobacillus* and *Bifidobacterium*) beneficial to large intestine [Grzelak 2006], thus limiting a risk of development of some diet-dependent diseases, e.g. colorectal cancer.

Both the yield and nutritional value of the onion are mainly controlled by genetic factor, which in turn are heavily modified by environmental factors. Mineral fertilization, especially nitrogen, significantly affects the yield as well as the quality of onion bulb and other vegetables [Rolbiecki at al. 2000, 2012]. The study presented by Cecílio Filho et al. [2009] and Woldetsadik et al. [2002] noted the relationship between the increase of dry matter in *Allium cepa* bulbs and increasing of the nitrogen fertilizer levels. Additionally Woldetsadik et al. [2002] reported also the rise of the bulb yield. On the other hand, no significant effects of increasing N levels on the dry matter content in shallot bulbs [Woldetsadik et al. 2003, Woldetsadik and Workneh 2010] and onion bulbs [Zeka et al. 2009] were observed. At the same time Woldetsadik and Workneh [2010] and Zeka et al. [2009] reported the rise but Woldetsadik et al. [2003] noted decrease of the bulb yield with increasing of nitrogen fertilization levels. Olle and Williams [2014] found that fertilized onion had a greater vitamin C content than non-fertilized ones. In the study provided by Kołota et al. [2013] no significant effects were observed on the bunching onion vitamin C as well as the content of dry matter, total sugar and yield due to the nitrogen fertilization. According to Woldetsadik and Workneh [2010] increasing nitrogen fertilization levels also did not impact significantly the total and reducing sugar levels. Due to its shallow poorly-developed root system, onion has a low capacity for using nutrients from soil. However, the rate of mineral fertilisation in onion depends on the richness of soil with available nutrients, the rate of organic fertilisers and water relations. The nutrition requirements of onion in terms of nitrogen, namely the amount of the nutrient uptaken by the plant over the vegetation period, depend on the yield size. With the yield of 45 t ha^{-1} onion uptakes 128 kg of nitrogen.

Applying mineral fertilisation to increase the yield often leads to a change in the chemical composition of vegetables. The changes concern both mineral and organic nutrients; proteins, vitamins, sugar, which determine the nutritive value of vegetables [Kołota and Dobromilska 1992, Gurgul et al. 1998]. There is no studies on the effect of 60, 120 and 180 nitrogen doses on the nutritional value and also marketable yield of onions and correlation between nitrogen fertilisation and features of onion. In scientific research is looking for the optimal plant species and even varieties of fertilizer doses that are to perform building and nutritional functions, while limiting their use.

The aim of the study has been to determine the effect of a varied nitrogen fertilisation on the marketable yield and content of dry matter, vitamin C, monosaccharides and total sugar in 'Efekt' and 'Kutnowska' onion.

MATERIAL AND METHODS

A field experiment was performed over 2003–2006 at Korytowo, about 30 km away from Bydgoszcz, northwards. The research was performed on a good rye complex soil, representing soil valuation class IIIb, with a neutral reaction, with a high richness with phosphorus, potassium and available magnesium and the content of organic carbon of 1.1%. The experiment was set up in 'split-plot', in three reps. The research has involved two factors: I – onion cultivars (Kutnowska, Efekt), II – nitrogen fertilisation rate (0, 60, 120, 180 kg $N \cdot ha^{-1}$).

The onion forecrop was made up by potato under which, in autumn, FYM was applied at the rate of 30 t ha^{-1}. Potassium and phosphorus fertilisers were sown in autumn under pre-winter plough at the rates considering the content of those elements in soil and nutrition requirements in onion. 40% superphosphate was applied at the rate of 50 kg $P_2O_5 \cdot ha^{-1}$ and 60% potassium salt at the rate of 100 kg $K_2O \cdot ha^{-1}$. Mineral nitrogen fertilisation was divided into the start rate, applied with the spring soil cultivation, at the rate of 60 kg N·ha^{-1} (34% ammonium nitrate), as well as the post-plant-emergence rates (0; 60; 120 kg N·ha^{-1} 34% ammonium nitrate).

Onion was sown in the first decade of April at the rate of 5–6 kg·ha^{-1}, which resulted in the plant density of about 100 plants per m^2. Weed control was mechanically performed. Protection treatments were made compliant with the guidelines of the Institute of Plant Protection to combat diseases and pests.

The Sielaninov coefficient was calculated according to Molga (1986) from the equation: $K = P \times 10 / \Sigma t$, where: K – Sielaninov coefficient, P – sum of rainfall, Σ t – sum of average air temperature. The value of K in the range 0 to 0.5 means drought, 0.6 to 1.0 – dryness, and the value above 1.0 means humid conditions.

The weather conditions over the research years varied (tab. 1–3). The 2003 vegetation period can be considered cool and dry. The Sielaninov coefficient was 0.60. The year 2004 was, of all the research years, a cool period with an uneven precipitation distribution. The Sielaninov coefficient was 0.72. The year 2005, in terms of vegetation period temperature, was most similar to the mean for 1951–2005 (14.2°C), the mean temperature was 0.1°C higher. The precipitation in that period, on the other hand, was 80.1 mm lower than in the many-year period. The Sielaninov coefficient was 0.85. The 2006 vegetation period, on the other hand, can be considered warm and humid. The Sielaninov coefficient was 1.24.

Onion was harvested in two stages. At the first stage (the second and third decade of September) onion was ploughed out when 70% of onion foliage got broken. To dry up, onion remained in the field for about 10 days. From each field 5 kg of onion bulbs was sampled by hand for the following to be assayed: dry matter with the oven-dry method [Krełowska-Kułas 1993], vitamine C with the Tillmans method according to PN-A-04019 [1998], and monosaccharides and total sugar [Talburt and Smith 1987].

Table 1. Mean air temperature (ºC) during the onion vegetation period (Mochełek)

Years	Months							Mean
	IV	V	VI	VII	VIII	IX	IV–IX	1951–2005
2003	6.4	14.4	17.6	19.2	18.4	13.6	14.9	14.2
2004	7.5	11.3	14.7	16.4	17.9	12.7	13.4	14.2
2005	7.4	12.2	14.9	19.4	16.3	14.8	14.2	14.2
2006	7.1	12.5	16.8	22.4	16.6	15.2	15.1	14.2

Table 2. Mean rainfall (mm) during the onion vegetation period (Mochełek)

Years	Months							Mean
	IV	V	VI	VII	VIII	IX	IV–IX	1951–2005
2003	13.3	12.1	34.3	88.8	17.8	11.2	177.5	285.4
2004	12.1	44.4	35.8	41.8	85.6	24.8	244.5	285.4
2005	23.8	69.5	30.7	40.2	20.9	17.9	203.0	285.4
2006	45.0	63.5	21.8	30.4	144.5	41.5	316.7	285.4

Table 3. The hydrothermal Sielaninov coefficient (Mochełek)

Years	Months						
	IV	V	VI	VII	VIII	IX	IV–IX
2003	0.69	0.47	0.65	1.49	0.31	0.28	0.60
2004	0.64	1.27	0.80	0.82	0.15	0.65	0.72
2005	1.07	1.84	0.69	0.67	0.42	0.40	0.85
2006	2.11	1.64	0.43	0.44	2.23	0.61	1.24

The results recorded in the experiments were exposed to the analysis of variance compliant with the model of the field experiments. The synthesis of multiple experiments was made in the mixed error model. To evaluate the significance of differences across object means, Tukey's range test was used at the level of significance of P = 0.05.

RESULTS AND DISCUSSION

The marketable yields of both 'Kutnowska' and 'Efekt' varieties were higher with increasing nitrogen doses (tab. 4, figs 1 and 2). In turn, both cultivars were characterized by the opposite effect of increasing nitrogen doses on dry matter content in onions (figs 1 and 2). The content of reduction sugars significantly decreased in the 'Kutnowska' variety, and increased in the 'Efekt' variety along with the increase in nitrogen doses (figs 1 and 2). There were no significant interactions of varieties and fertilizers on total sugar content. In the 'Kutnowska' variety the content of vitamin C decreased with the increase of nitrogen doses, whereas in the variant 'Efekt' a significant positive correlation was found (figs 1 and 2).

The chemical composition of onion comes from genetic conditioning. It can, however, be modified by agrotechnical and climatic factors. The content of dry matter in onion determines mostly the direction of use of that material. According to Doruchowski [1995], Babik [2004], onion for immediate consumption and freezing should show a low content of dry matter (7–8%), while a high content of that nutrient (17%) is especially desirable as material for the production of dry vegetable and for storage. In the present research, as a result of increasing nitrogen fertilisation, in the onion cultivars analysed, the content of dry matter decreased, as compared with the samples collected from the object with no nitrogen fertilisation (tab. 4). There were shown, however, no significant differences in the content of dry matter across cultivars. In the cool vegetation period with an uneven rainfall distribution (2004) the onion bulbs accumulated the lowest amount of dry matter (tab. 4), whereas after a warm and dry period (2005), the highest content of dry matter was recorded (20.0% points increase as compared to the year 2004).

The content of sugar in onion determines the applicability of the material to a specific use. According to Matuszak and Pędziński [2003], a higher content of sugar, especially monosaccharides, intensifies the darkening of the dry onion flesh. According to Schena and Davis [2000], the tendency to darkening is considered a negative trait since darkened flesh triggers unfavourable sensory impressions and such onion is not accepted by consumers.

Table 4. The content of yield ($kg \cdot m^2$)

Cultivars	Years	Nitrogen fertilisation ($kg\ N \cdot ha^{-1}$)				Mean
		0	60	120	180	
Kutnowska	2003	4.87	7.19	7.84	9.32	7.31
	2004	4.36	7.36	8.11	9.31	7.29
	2005	2.59	4.09	5.09	5.49	4.36
	2006	3.49	3.33	5.22	5.51	4.39
Mean		3.82	5.49	6.56	7.41	5.82
Efekt	2003	4.19	5.8	6.38	6.99	5.84
	2004	4.19	5.58	6.04	6.85	5.67
	2005	2.07	3.53	5.75	5.89	4.31
	2006	1.97	2.52	4.13	6.36	3.75
Mean		3.11	4.36	5.58	6.52	4.89
Mean for fertilisation		3.70	5.28	6.41	7.17	5.64

$LSD_{0.05}$ for: cultivars = ns; fertilisation = 1.09; cultivars × fertilisation = ns

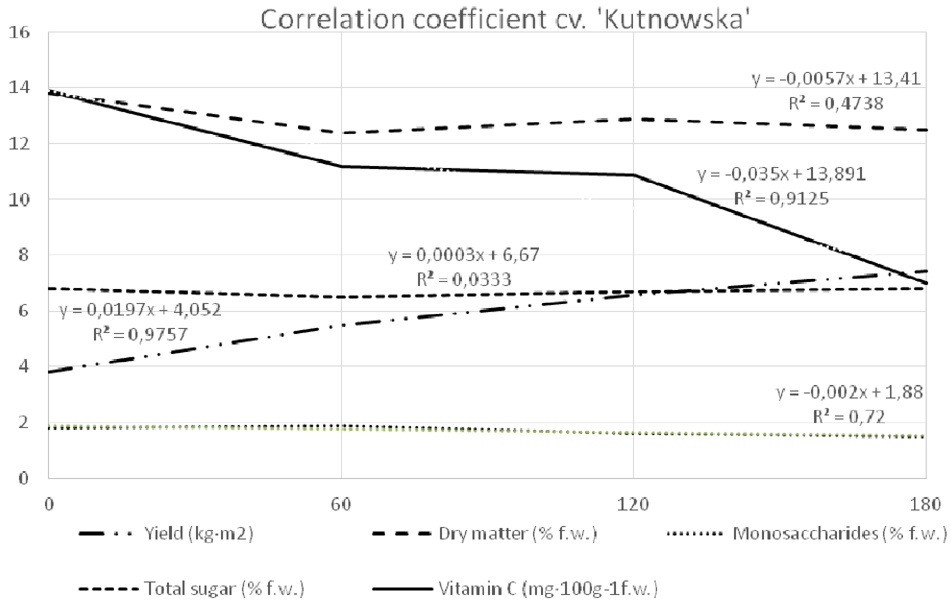

Fig. 1. Correlation coefficient between nitrogen fertilization and yield, dry matter, monosaccharides, total sugar and Vitamin C in cv. 'Kutnowska'

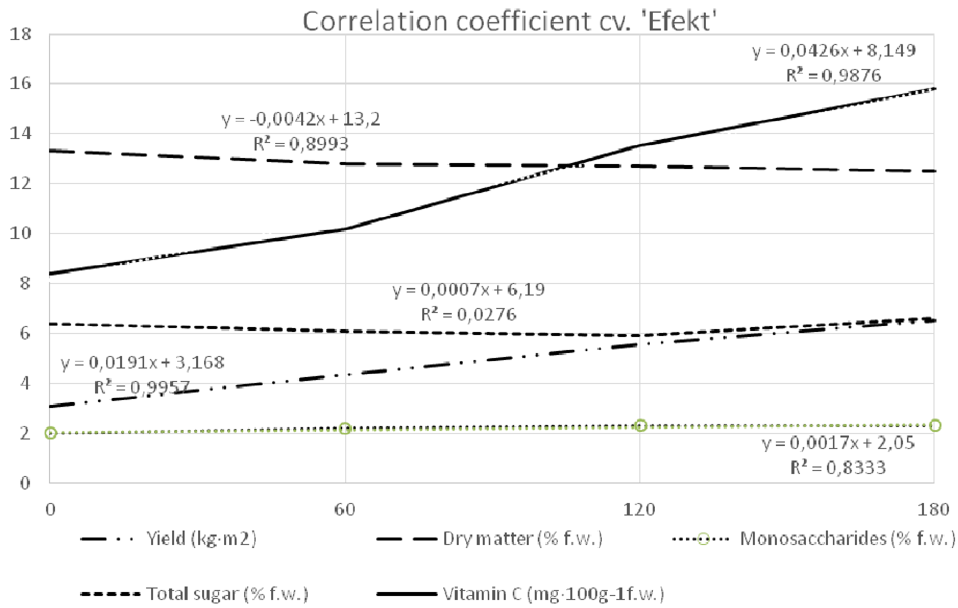

Fig. 2. Correlation coefficient between nitrogen fertilization and yield, dry matter, monosaccharides, total sugar and Vitamin C in cv. 'Efekt'

Table 5. The content of dry matter (% f.w.)

Cultivars	Years	Nitrogen fertilisation (kg N·ha^{-1})				Mean
		0	60	120	180	
Kutnowska	2003	14.8	12.0	13.7	13.7	13.6
	2004	12.0	10.6	11.6	10.7	11.2
	2005	14.6	14.0	13.5	13.2	13.8
	2006	13.7	13.0	12.8	12.5	13.0
Mean		13.8	12.4	12.9	12.5	12.9
Efekt	2003	13.1	13.2	12.3	14.1	13.2
	2004	12.1	11.3	12.4	11.1	11.7
	2005	14.6	13.7	13.4	13.0	13.7
	2006	13.3	12.8	12.5	11.8	12.6
Mean		13.3	12.8	12.7	12.5	12.8
Mean for fertilisation		13.5	12.6	12.8	12.5	12.9

$LSD_{0.05}$ for: cultivars = ns; fertilisation = 0.9; cultivars × fertilisation = ns

Tabela 6. The content of monosaccharides (% f.w.)

Cultivars	Years	Nitrogen fertilisation (kg N·ha^{-1})				Mean
		0	60	120	180	
Kutnowska	2003	2.0	2.2	1.4	1.3	1.7
	2004	1.8	1.7	1.3	1.7	1.6
	2005	1.6	1.9	2.1	1.6	1.8
	2006	1.8	1.9	1.6	1.5	1.7
Mean		1.8	1.9	1.6	1.5	1.7
Efekt	2003	1.7	2.5	2.5	2.0	2.2
	2004	2.2	1.9	2.0	1.9	2.0
	2005	2.0	2.1	2.4	2.6	2.3
	2006	2.1	2.3	2.4	2.8	2.4
Mean		2.0	2.2	2.3	2.3	2.2
Mean for fertilisation		1.9	2.1	2.0	1.9	2.0

$LSD_{0.05}$ for: cultivars = 0.204; fertilisation = ns; cultivars × fertilisation = 0.349

Table 7. The content of total sugar (% f.w.)

Cultivars	Years	Nitrogen fertilisation (kg N·ha^{-1})				Mean
		0	60	120	180	
Kutnowska	2003	7.1	6.5	6.4	5.8	6.5
	2004	7.2	7.3	8.0	8.1	7.7
	2005	5.9	5.4	5.9	6.6	6.0
	2006	6.9	6.7	6.6	6.7	6.7
Mean		6.8	6.5	6.7	6.8	6.7
Efekt	2003	6.4	5.6	4.9	6.6	5.9
	2004	6.8	6.9	7.0	6.9	6.9
	2005	6.0	5.7	5.7	6.2	5.9
	2006	6.4	6.0	6.0	6.6	6.3
Mean		6.4	6.1	5.9	6.6	6.2
Mean for fertilisation		6.6	6.3	6.3	6.7	6.5

$LSD_{0.05}$ for: cultivars = 0.220; fertilisation = 0.306; cultivars × fertilisation = ns

Table 8. The content of vitamin C (mg·kg^{-1} f.w.)

Cultivars	Years	Nitrogen fertilisation (kg·ha^{-1})				Mean
		0	60	120	180	
Kutnowska	2003	130.0	104.0	129.6	65.2	107.2
	2004	162.9	143.0	142.3	84.1	133.1
	2005	138.8	85.1	54.0	46.3	81.1
	2006	124.0	115.9	109.2	84.3	108.4
Mean		138.9	112.0	108.8	70.0	107.4
Efekt	2003	81.0	84.0	98.0	113.9	94.2
	2004	109.2	115.0	129.8	163.8	129.5
	2005	77.6	94.1	151.1	168.7	122.9
	2006	68.5	114.0	162.0	185.9	132.6
Mean		84.1	101.8	135.2	158.1	119.8
Mean for fertilisation		111.5	106.9	122.0	114.1	113.6

$LSD_{0.05}$ for: cultivars = ns; fertilisation = ns; cultivars × fertilisation = 45.3

The content of the sugar assayed in onion varied for different cultivars (tabs 5 and 6). The cultivars varied in genetically-conditioned content of monosaccharides and total sugar in onion bulbs. In 'Efekt' the level of monoscaccharides in fresh matter was 0.5% points higher than in 'Kutnowska', which was also statistically confirmed (tab. 5). The inverse relationship was observed in the total sugars content, 'Kutnowska' has 0.5% points higher content of total sugars than 'Efekt' (tab. 6). The analysis of variance did not show a significant effect of applying a higher nitrogen rate on the content of monosaccharides in onion. However, it demonstrated a significant effect of the interaction of the nitrogen fertilisation rates, depending on the cultivar, on a given trait (tabs 5 and 6). An increase in nitrogen fertilisation resulted in a different reaction of cultivars to the content of monosaccharides in onion. The nitrogen rate of 120 and 180 kg $N \cdot ha^{-1}$ applied under 'Kutnowska' onion significantly decreased the content of monosaccharides, as compared with the rate of 60 kg $N \cdot ha^{-1}$. 'Efekt' onions, on the other hand, showed a different reaction, with a tendency to an increase in the content of that nutrient. The content of monosaccharides in the onion cultivars studied differed slightly across the years (tab. 5), while the temperature and moisture conditions over the vegetation period differentiated the content of total sugar in the onion of the cultivars studied (tab. 6). In the year 2004, showing a lower mean total precipitation than the many-year mean and with a lower mean temperature than the mean for 1951–2051, the highest content of total sugar was recorded in onion bulbs of both cultivars, 7.7 and 6.9%, respectively.

In terms of increasing nitrogen fertilisation, the cultivars reacted differently in their content of vitamin C in onion (tab. 7). The analysis of variance has shown an interaction between the cultivar and the rate, which correlatively affected the content of vitamin C in bulbs (fig. 2). A significantly increased content of vitamin C in onion was recorded for 'Efekt' where, during the vegetation period, nitrogen was applied at the rate of 180 kg $N \cdot ha^{-1}$. In 'Kutnowska' onions, on the other hand, the nitrogen rate of 180 kg $N \cdot ha^{-1}$, resulted in a significant decrease in the content of that vitamin. The highest content of vitamin C was found in the cultivars of onion collected in the year 2004 when mean temperature and rainfall in the vegetation period was lower than the mean for 1951–2005 (tab. 4).

The analysis of correlation of the selected chemical composition of bulbs of the onion cultivars investigated showed a negative dependence between the content of dry matter, content of total sugar and monosaccharides (tab. 8). The lower the content of dry matter in onion bulbs, the higher the content of total sugar in onion and the lower the content of monosaccharides.

CONCLUSIONS

The commercial yields of both Kutnowska and 'Efekt' varieties were higher with increasing nitrogen doses.

The fertilisation with nitrogen resulted in a decrease in the content of dry matter in the onion bulbs.

'Kutnowska' showed a higher content of total sugar and, at the same time, a lower content of monosaccharides than 'Efekt'.

'Efekt' reacted with an increase in the content of vitamin C and monosaccharides as affected by 120 and 180 rates of nitrogen fertilisation. A different reaction was reported for 'Kutnowska'.

REFERENCES

Babik, J. (ed.) (2004). Organic farming methods onion. Materials for farmers collective work. Krajowe Centrum Rolnictwa Ekologicznego – Regionalne Centrum Doradztwa Rozwoju Rolnictwa i Obszarów Wiejskich w Radomiu, Radom, 42 pp. (in Polish).

Cecílio Filho, A.B., May, A., Porto, D.R., Barbosa, J.C. (2009). Crescimento da cebola em função de doses de nitrogênio, potássio e da população de plantas em semeadura dieta. Hortic. Bras., 27(1), 49–54.

Dini, I., Tenore, G.C., Dini, A. (2008). Chemical composition, nutritional value and antioxidant properties of *Allium cepa* L. var. tropeana (red onion) seeds. Food Chem., 107, 613–621.

Doruchowski, R.W. (1995). New trends in breeding of onion. Plant Breed. Seed Prod., 1, 13–17 (in Polish).

Gökçe, A.F., Kaya, C., Serçe, S., Özgen, M. (2010). Effect of scale color on the antioxidant capacity of onions. Sci. Hortic., 123, 431–435.

Grzelak, K. (2006). Cebula jako źródło prebiotyków w okresie jesienno-zimowym. Żywn. Nauka Technol. Jakość, 2(47) Suppl., 67–71.

Gurgul, E., Kołota, E., Herman, B., Biczak, R. (1998). Wpływ nawożenia magnezem i potasem na zawartość cukrów, witaminy C oraz chlorofilu w liściach cebuli zwyczajnej i szczypiorku. Zesz. Nauk. AR Wrocław, Rolnictwo, 73, 347, 155–164.

Jarosz, M., Respondek, W. (2010). The principles of proper nutrition. In: Practical guide diet. Jarosz, M. (ed.). Instytut Żywności i Żywienia, 88–95 (in Polish).

Kołota, E., Adamczewska-Sowinska, K., Uklanska-Pusz, C. (2013). Response of Japanese bunching onion (*Allium fistulosum* L.) to nitrogen fertilization. Acta Sci. Pol. Hortorum Cultus, 12(2), 51–61.

Kołota, E., Dobromilska, R. (1992). Effect of nitrogen and phosphorus on yield and mineral composition of brussels sprouts. Vol. II. Nutritional status and nutrient content heads. Rocz. Nauk Rol., 109(3), 107–119 (in Polish).

Krełowska-Kułas, M. (1993). Badanie jakości produktów spożywczych. PWE, Warszawa.

Matuszak, W., Pędziński, M. (2003). The suitability for processing of new varieties and strains of onion “consistently” Nochowo. National Conference, “Growing of vegetables for processing”, Skierniewice, 2 October 1993 (in Polish).

Molga, M. (1986). Podstawy klimatologii rolniczej. PWRL, Warszawa, 544–547.

Olle, M., Williams, I.H. (2014). The effect of organic fertilizers on the chemical quality of onions. Acta Hortic., 1054, 319–324.

Osmont, K., Arnt, C., Goldman, J. (2003). Temporal aspects of onion-induced antiplatelet activity. Plant Foods Hum. Nutr., 58, 27–40.

Pérez-Gregorio, R.M., García-Falcón, M.S., Simal-Gándara, J., Rodrugues, A.S., Almeida, D.P.F. (2010). Identification and quantification of flavonoids in traditional cultivars of red and white onions at harvest. J. Food Compos. Anal., 23, 592–598.

PN-A-04019:1998. Produkty spożywcze. Oznaczanie zawartości witaminy C.

Rolbiecki, St., Rolbiecki, R., Rzekanowski, Cz., Żarski, J. (2000) The influence of sprinkler irrigation on yields of some vegetable crops in the region of Bydgoszcz, Poland. Acta Hortic., 537 (2), 871–877.

Rolbiecki, St., Rolbiecki, R., Czop, P. (2012). Effect of drip irrigation and nitrogen fertilization on yields of onion cv. ‘Kutnowska’ on the sandy soil in the region of Bydgoszcz. Infrastruk. Ekol. Teren. Wiej., 2(1), 183–189 (in Polish).

Sêdo, A., Krejĉa, J. (1988). Rośliny źródłem przypraw. PWRiL, Warszawa.

Schena, M., Davis, R.W. (2000). Technology standards for microarray research. In: Microarray Biochip Technology, Schena, M. (ed.). Eaton Publishing, Natick, MA, 1–18.

Strzelecka, H., Kowalski, J. (2000). Encyklopedia zielarstwa i ziołolecznictwa. PWN, Warszawa.

Talburt, W., Smith, F.O. (1987). Potato Processing. AVI Van Nonstrand Reinhold Company, New York.

Vidyavati, H., Manjunatha, H., Hemavathy, J., Srinivasan, K. (2010). Hypolipidemic and antioxidant efficacy of dehydrated onion in experimental rats. J. Food Sci. Technol., 47(1), 55–60.

Woldetsadik, K., Gertsson, U., Ascard, J. (2002). Response of shallots to N, P, and K fertilizer rates. Trop. Agric., 79(4), 205–210.

Woldetsadik, K., Gertsson, U., Ascard, J. (2003). Shallot yield, quality and storability as affected by irrigation and nitrogen. J. Hortic. Sci. Biotech., 78(4), 549–553.

Woldetsadik, S.K., Workneh, T.S. (2010). Effects of nitrogen levels, harvesting time and curing on quality of shallot bulb. Afr. J. Agric. Res., 5(24), 3342–3353.

Zeka, N., Nasto, T., Balliu, A. (2009). The influence of N sources and fertilization doses on dry onion (*Allium cepa* L.) yield and bulbs shelf life. Acta Hortic., 830, 493–496.