

THE EFFECT OF NITROGEN FERTILIZATION METHODS ON YIELD AND CHEMICAL COMPOSITION OF PUMPKIN (*CUCURBITA MAXIMA*) FRUITS BEFORE AND AFTER STORAGE

Anita BIESIADA¹, Agnieszka NAWIRSKA², Alicja KUCHARSKA²,
Anna SOKÓŁ-ŁĘTOWSKA²

¹Department of Horticulture

²Department of Fruit, Vegetables and Grain Technology
Wrocław University of Environmental and Life Sciences
pl. Grunwaldzki 24 A, 50-363 Wrocław, Poland

Received: March 20, 2009; Accepted: May 6, 2009

Summary

In field experiment pumpkin of Amazonka and Karowita cvs (*Cucurbita maxima*) were fertilized at the rate of 200 kg N·ha⁻¹ in the following methods: 1-100 kg N·ha⁻¹ preplant broadcasting + 100 kg N·ha⁻¹ as top dressing in form of 4 foliar sprays, 2-100 kg N·ha⁻¹ preplant band placement on strips of 50 cm wide + 100 kg N·ha⁻¹ as top dressing broadcasted on total area of field, 3- placement of N in rate of 200 kg N·ha⁻¹ as a nests placement 25 cm apart from plant, 4-organic fertilization with composted cattle manure at the rate of 40 t·ha⁻¹ applied in 50 cm wide strips. There were estimated total and marketable yield and chemical composition of fruits before and after 90 days of storage. Broadcasting of nitrogen gave the higher yield of fruit than banded or nested placement of this nutrient. Banded placement of nitrogen affected in the highest vitamin C content as well as higher levels of total and reducing sugars and carotenoids than in other methods of nitrogen placement. Before storage the fruits had higher amounts of soluble solids, dry matter, carotenoids, vitamin C as well as total and reducing sugars than after 90 days of storage.

key words: *Cucurbita maxima*, cultivar, yield, nutritional value, methods of N placement, storage

INTRODUCTION

Pumpkin (*Cucurbita maxima*) is a vegetable not so popular in Poland although its fruit harvested at physiologically matured stage is a rich source of valuable nutrients. The flesh of pumpkins contain vitamin C (9-20 mg·100g⁻¹), thiamine (0.05 mg), riboflavin (0.11 mg), niacin (0.6 mg), vitamin B₆ (0.06 mg), folates (0.16-0.20 µg), vitamin E (0.06 mg), vitamin K (1.1 µg), β-carotene (2-10 mg·100g⁻¹), and nutrients like potassium, phosphorus, magnesium, iron, selenium

as well as (USDA National Nutrient Database 2004). Pumpkin fruit is a suitable and desired raw material for processing of juices, jams, marinates, children's food and as colorant of spaghetti and cakes (Muntean *et al.* 2002, Danilchenko 2002).

This species is cultivated on a wide range of soils, but the best are those with high content of organic matter. The total nitrogen recommendation for pumpkin amounts 150-200 kg N·ha⁻¹ where 1/2 to 2/3 of total dose should be applied before seed sowing and the rest as top dressing when the first flowers occur on plants (Sady 2000). Vining cultivars of *Cucurbita maxima* are planted in wide rows, where vines are allowed to run, but newer ones that have more bushy growth habit closer row spacing is more suitable. In this case the large area of soil is free from the plants for a considerably long time what effected in leaching of nitrogen. Placing the fertilizer in a band or nests reduce contact with soil microorganisms, decrease immobilization of both ammonium and nitrate. Placement of nitrogen also slow down NH₄ to NO₃ conversion which diminishes losses of this nutrient by denitrification and leaching (Malhi *et al.* 2001).

The storage life of pumpkin fruit varies from 3 to 6 months and depend on many factors, such as cultivar, precipitation and temperature conditions during plant growing season, fertilization, term of harvesting and storage conditions (Arvayo-Ortiz *et al.* 1994). According to Gajewski (2001) excessive nitrogen fertilization decreased in many cases storability of vegetables. But many authors stated that there is only limited effect of nitrogen on storage losses (Slangen *et al.* 1990, Freyman *et al.* 1991).

The objectives of the study was to estimate the effect of nitrogen fertilization method on yielding and chemical composition of two pumpkin cultivars before and after their storage.

MATERIAL AND METHODS

The three year field experiment was carried out in the Experimental Station of Wrocław Environmental and Life Sciences University on fine clay soil containing 1.8% of organic matter, with pH = 7.05 as well as high content of phosphorus (90-125 mg P·dm⁻³) potassium (220-240 mg K·dm⁻³) and magnesium (80-100 mg Mg·dm⁻³).

A two factorial experiment was established in a split-plot design in four replications. The plot area was 6.0 m² (3.0x2.0m). There were estimated different methods of nitrogen application in growing of Amazonka and Karowita cultivars of *Cucurbita maxima* species. Nitrogen was supplied in dose of 200 kg N·ha⁻¹ in following way: 1-100 kg N·ha⁻¹ broadcasted before seed sowing and 100 kg N·ha⁻¹ as foliar fertilization sprayed four times, 2-100 kg N·ha⁻¹ by placing in 50 cm wide bands before seed sowing + 100 kg N·ha⁻¹ as top dressing on total area of plot, 3- placement of N in rate of 200 kg N·ha⁻¹ in form of nested pellets, 4-organic fertilization with 40 t·ha⁻¹ of composted cattle manure applied in 50 cm wide strips. Ammonium nitrate was used as broadcast and banded fertilization in 1 and 2 treatments. In treatment 3 with the placement fertilization as nested pellets, ammonium sulphate was applied after seed sowing at distance

25 cm to each plant, and placed 10 cm depth. Seed sowing was performed directly in spacing 1x1 m in second decade of May.

Crop management was conducted according to commonly accepted recommendations for this species. Harvest took place in the second week of September. There were estimated total, marketable yield and average weight of fruit.

At harvest 4 fruits per treatment were sampled for chemical analysis, the rest of the crop was kept in storage room with gravity ventilation at temperature 10°C and RH 75%. After 90 days of storage fruit samples were collected in the same amounts. They were prepared by cutting of pumpkin fruit, removing the placenta and seeds and milling the flash with blender. Immediately after harvesting and at the end of storage there were assayed contents of vitamin C (Tillmans method according PN-90/A-75101/11), total carotenoids (Rumińska *et al.* 1990), total and reducing sugars (by Lane-Eynon method), soluble solids in degree Brix using refractometer (ATAGO-POCTEL), as well as dry matter by drying to constant weight at 105°C (PN-90/A-75101/03). Nitrates were determined using an ion-selective electrode. The contents of macronutrients: phosphorus, potassium, magnesium and calcium were determined according to Nowosielski method (Nowosielski 1974).

Data collected from 3 years were subjected to analysis of variance, means were separated by the Tuckey's test at $P=0.05$.

RESULTS AND DISCUSSION

Karowita cv. produced bigger fruits than Amazonka cv. which resulted in significantly higher total and marketable yield (Table 1). Fertilization method effected the yielding of both pumpkin cultivars. The highest total yield of pumpkin was observed in treatment fertilized with 100 kg N·ha⁻¹ as pre-plant broadcasting of total plot areas, combined with top dressing by foliar fertilization introduced in four sprayings (4x25 kg N·ha⁻¹) during intensive growth of plants. Similar yields were noticed also in treatment fertilized with cattle manure at rate of 40 t·ha⁻¹ used as side banded. In treatments with side banded as well nested application of mineral N the total yield of pumpkin fruit was lower. The method of nitrogen application influenced the marketable yield of tested cultivars of *Cucurbita maxima*. The most efficient method was traditional pre-plant N broadcast fertilization combined with foliar fertilization as top dressing. Only slightly lower yield was obtained in treatment with pre-plant manure banded. In experiment both in-soil banded or nested application of N caused significant decrease of marketable yield of pumpkin. Also Sady *et al.* (2001) stated that placement technique slightly reduced yield of white cabbage. According to Malhi *et al.* (2001) the benefits of pre-plant N banding over broadcasting varies greatly under environmental conditions. Banding of N generally has greater benefits when moisture level, yield potential and N use are high. Under drier conditions the soil disturbance caused by banding may lead to loss of moisture great enough to reduce yields.

Tabela 1. The effect of fertilization methods with nitrogen on yield of two cultivars of pumpkin (*Cucurbita maxima*) (mean for 2006-2008)

Treatments		Total yield t·ha ⁻¹	Marketable yield t·ha ⁻¹	Average weight of marketable fruit kg
Karowita	1*	54.61	47.36	2.38
	2	55.49	42.73	2.20
	3	47.73	41.61	2.00
	4	54.35	45.46	2.43
Mean		51.04	44.29	2.20
Amazonka	1	31.86	25.95	1.10
	2	26.26	22.44	0.90
	3	25.19	20.33	0.87
	4	31.42	25.26	1.00
Mean		28.68	23.74	0.97
Mean	1	42.73	37.15	1.74
	2	37.37	32.58	1.55
	3	36.46	30.97	1.43
	4	42.88	35.36	1.62
Mean		39.86	33.98	1.58
LSD _{0.05} for:				
cultivar		3.02	3.62	0.10
fertilization method		4.39	4.86	0.26

*fertilization methods: 1- preplant broadcasted at the rate 100 kg N·ha⁻¹ + foliar fertilization 4x25 kg N·ha⁻¹, 2- preplant in-soil banding +top dressing 2x 50 kg, 3- placing 200 kg N·ha⁻¹ in the soil as nests, 4- placing manure at the rate of 40 t·ha⁻¹ as bands in soil before seeding

The fruits of pumpkin, analysed directly after harvest, contained higher levels of soluble solids, dry matter, carotenoids as well as total and reducing sugars and vitamin C concentration than those tested after 90 days of storage (Table 2, 3). This is partly in agreement to Arvayo-Ortiz *et al.* (1994) and Bycroft *et al.* (1999). According to Niewczas & Mitek (2007) there was not statistically significant changes in concentration of total sugars and carotenoids before and after storage.

Taking into account soluble solids, dry matter, carotenoids and vitamin C contents, Amazonka cv. featured higher biological value than Karowita cv. before and after storage. The content of carotenoids and vitamin C in Amazonka fruits was higher than in Karowita by over 50% and 16.1% after harvest and by 49.5% and 46.02% higher after storage, respectively. The effect of fertilization method on concentration of organic constituents was less visible but significant. After the harvest fruits of pumpkin fertilized organically characterized higher level of soluble solids, dry matter and carotenoids than in remaining treatments. Also Danilchenko (2002) observed that organically grown pumpkins accumulated greater amounts of dry matter, and β-karotene while conventionally grown greater amounts of vitamin C. Pre-plant banded application of mineral nitrogen ensured satisfactory nutritional value of pumpkin fruit with the highest vitamin

C content and high level of reducing and total sugars, carotenoids, soluble solids and dry matter.

Table 2. Effect of nitrogen fertilization methods on content of dry matter, soluble solids, carotenoids and vitamin C in pumpkin fruit before and after storage (mean for 2006-2008)

Treatment	Soluble solids		Dry matter		Carotenoids		Vitamin C	
	^o Brix		%		mg·100g ⁻¹ f.m.			
	1**	2	1	2	1	2	1	2
Karowita								
1*	8.20	7.70	11.51	8.46	8.47	9.22	27.98	15.59
2	8.35	7.95	13.04	9.45	9.60	8.19	31.54	16.77
3	8.05	6.10	10.62	8.57	7.56	4.79	29.91	11.12
4	9.45	8.60	10.34	9.68	8.45	6.64	22.16	15.29
Mean	8.51	7.59	11.38	9.04	8.52	7.21	27.90	14.69
Amazonka								
1	8.05	8.60	11.70	9.96	14.01	13.25	29.61	29.30
2	9.55	9.80	13.31	12.17	20.38	17.61	34.90	28.41
3	8.40	9.00	11.97	11.70	16.16	13.42	32.06	22.17
4	10.95	8.50	17.59	10.36	23.87	12.75	36.85	28.95
Mean	9.24	8.98	13.64	11.05	18.61	14.26	33.36	27.21
1	8.12	8.15	11.60	9.21	11.24	11.23	28.79	22.44
2	8.95	8.87	13.17	10.81	14.99	12.90	33.22	22.59
3	8.22	7.55	11.29	10.13	11.86	9.10	30.98	16.64
4	10.20	8.55	13.96	10.02	16.16	8.77	29.50	22.12
Mean	8.87	8.28	12.51	10.04	13.56	10.73	30.63	20.95
LSD _{0.05} for: A cultivar, B fertilization method, interaction AxB								
A	0.53	0.72	1.10	1.09	1.32	1.46	1.65	1.57
B	0.46	0.63	1.06	0.86	1.10	0.93	1.36	1.42
AxB	0.39	n.s.	n.s.	n.s.	0.96	n.s.	n.s.	0.96

* Note: see Table 1; ** chemical analysis 1- before storage, 2- after storage

Table 3. Effect of nitrogen fertilization methods on content of total and reducing sugars in pumpkin fruit before and after storage (mean for 2006-2008)

Treatment	Reducing sugars		Total sugars	
			%	
	1**	2	1	2
Karowita				
1*	3.28	2.35	4.11	2.83
2	3.63	2.89	3.92	3.40
3	3.22	3.21	3.52	3.40
4	3.40	3.35	3.82	3.07
Mean	3.38	2.95	3.84	3.18
Amazonka				
1	3.35	2.28	4.20	2.56
2	3.32	2.68	4.30	2.87
3	3.63	2.47	4.32	3.12
4	3.52	2.50	3.92	2.85
Mean	3.46	2.48	4.19	2.85
1	3.31	2.31	4.15	2.69
2	3.47	2.78	4.11	3.13
3	3.42	2.84	3.92	3.26
4	3.46	2.92	3.87	2.96
Mean	3.42	2.71	4.01	3.01
LSD _{0.05} for: A cultivar, B fertilization method, interaction AxB				
A	n.s.	0.32	0.21	0.37
B	n.s.	0.37	0.26	0.28
AxB	n.s.	n.s.	0.30	n.s.

* Note: see Table 1; ** chemical analysis 1- before storage, 2- after storage

Amazonka accumulated slightly higher quantities of nitrates in fruits than Karowita. Average concentration of nitrates before storage amounted respectively 279 mg·kg⁻¹ f.m. in Amazonka and 245 mg·kg⁻¹ f.m. in Karowita fruit. The lowest nitrates concentration was observed in treatments with in-soil nested N application and fertilized with manure in rate of 40 t·ha⁻¹ (Table 4). This statement is in agreement to Sady *et al.* (2001). During storage decrease the level of nitrates in pumpkin fruits were observed. Average amount of nitrates before fruit storage ranged 261 mg·kg⁻¹ f.m. and after 90 days of storage was recorded decrease to the level amounting 203 mg·kg⁻¹ f.m. The plants fertilized both with cattle manure applied in banded form as well as with nitrogen placed in-soil as nests pellets accumulated rather lower amounts of phosphorus, potassium, magnesium and calcium. The concentration of P, K, Mg and Ca in pumpkin fruits after 90 days of storage was higher than in those subjected immediately after harvest.

Table 4. Effect of fertilization methods on chemical composition of pumpkin fruit before and after storage (mean for 2006-2008)

Treatment	NO ₃ mg·kg ⁻¹ f.m.		P		K		Mg		Ca	
	1**	2	1	2	1	2	1	2	1	2
Karowita										
1*	275.00	220.00	0.29	0.44	3.98	4.50	0.11	0.23	0.28	0.30
2	275.00	212.00	0.31	0.32	3.94	4.07	0.11	0.17	0.25	0.32
3	200.00	193.00	0.19	0.22	3.95	4.25	0.09	0.15	0.19	0.22
4	230.00	155.00	0.30	0.19	3.98	3.81	0.10	0.12	0.14	0.19
Mean	245.00	195.00	0.27	0.29	3.96	4.16	0.10	0.16	0.21	0.26
Amazonka										
1	280.00	230.00	0.27	0.34	4.10	5.25	0.08	0.17	0.16	0.34
2	300.00	220.00	0.21	0.30	4.20	4.68	0.12	0.18	0.13	0.30
3	287.00	190.00	0.18	0.29	3.98	5.50	0.08	0.21	0.13	0.29
4	250.00	210.00	0.16	0.27	3.95	4.63	0.09	0.19	0.11	0.27
Mean	279.25	212.50	0.20	0.30	4.06	5.01	0.09	0.18	0.13	0.30
1	277	225	0.28	0.39	4.04	4.87	0.09	0.20	0.22	0.32
2	287	216	0.26	0.31	4.07	4.37	0.11	0.18	0.19	0.31
3	243	191	0.19	0.25	3.96	4.87	0.09	0.18	0.16	0.26
4	240	182	0.23	0.23	3.96	4.22	0.09	0.16	0.13	0.23
Mean	261	203	0.23	0.29	4.01	4.58	0.09	0.17	0.17	0.28
LSD _{0.05} for: A cultivar, B fertilization method, interaction AxB										
A	30	n.s.	0.06	n.s.	n.s.	0.46	n.s.	n.s.	0.05	n.s.
B	32	n.s.	0.06	0.05	n.s.	0.32	n.s.	0.03	0.02	0.04
AxB	22	25	n.s.	0.06	n.s.	0.37	n.s.	n.s.	0.06	0.06

Note: see Table 2; means followed by the same letter do not differ significantly at P=0.05

This work was supported by the Polish Ministry of Science and Higher Education under Grant Nr N 310 089 32

CONCLUSIONS

1. Pre-plant broadcasting of nitrogen ensured significantly higher yield of pumpkin fruit than banded or nested placement of this nutrient.
2. Organically fertilized pumpkin had higher level of soluble solids and dry matter likewise carotenoids than in treatments with mineral N fertilization. Pre-plant banded application of mineral nitrogen assured also good nutritional value of pumpkin fruit expressed by vitamin C content as well as reducing and total sugars, carotenoids, soluble solids and dry matter.
3. The fruits of pumpkin analysed directly after harvest contained higher amounts of soluble solids, dry matter, carotenoids, total and reducing sugars and vitamin C than those tested after 90 days of storage.

4. Storage enhanced concentration of mineral constituents and decreased nitrates level in pumpkin fruits.
5. Plants fertilized with cattle manure had lower level of macronutrients Mg, Ca in fruit flesh.
6. Supply of N as banded organic fertilization as well as in-soil nested fertilization markedly decreased nitrates content in pumpkin fruit.

REFERENCES

- Arvayo-Ortiz R.M., Garza-Ortega S., Yahia F.M. 1994. Postharvest response of winter squash to hot-water treatment, temperature and length of storage. Hort. Technol. 4: 253-255.
- Bycroft B.I., Corrigan V.K., Irving D.E. 1999. Heat treatments increase sweetness and flesh colour of buttercup squash. New Zealand J. Crop and Hort. Sci. 27: 265-271.
- Danilchenko H. 2002. Effect of growing method on the quality of pumpkin and pumpkins products. Folia Hort. 14(2): 103-112.
- Freyman S., Toivonen P.M., Perrin P.W., Lin W.C., Hall J. 1991. Effect of nitrogen fertilization on yield, storage losses and chemical composition of winter cabbage. Can. J. Plant Sci. 71: 943-946.
- Gajewski M. 2001. Przechowalnictwo warzyw. Wydawnictwo SGGW, Warszawa.
- Malhi S.S., Grant C.A., Johnson A.M., Gill K.S. 2001. Nitrogen fertilization management for no-till cereal production in the Canadian Great Plains: a review. Soil & Tillage Research 60: 101-122.
- Muntean E., Modoran C., Socaciu C. 2002. High performance liquid chromatography analysis of carotenoid from pasta. Biul. Univ. Stiinte Agricole si Medicina 57: 234-237.
- Niewczas J., Mitek M. 2007. Wpływ przechowywania nowych odmian dyni olbrzymiej (*Cucurbita maxima*) na wybrane parametry składu chemicznego. Żywność. Nauka Technologia Jakość 5(54): 155-164. [in Polish]
- Nowosielski O. 1974. Metody oznaczania potrzeb nawożenia. PWRiL, Warszawa. [in Polish]
- Rumińska A., Suchorska K., Węglarz Z. 1990. Rośliny lecznicze i specjalne. SGGW AR Warszawa 108 pp. [in Polish]
- Sady W. 2000. Nawożenie warzyw polowych. Kraków 97 pp. [in Polish]
- Sady W., Wojciechowska R., Rożek S. 2001. The effect of form and placement of N on yield and nitrate content of white cabbage. Acta Hort. 563: 123-128.
- Slangen J.H., Titulaer H.H., Schroen G.J., Quik P., Everaarts A.P., De Morl C.P. 1990. Nitrogen fertilization of white cabbage. Field trials 1982-1987. Report 109. PAGW, Lelystad 59 pp. [in Dutch]
- USDA National Nutrient Database for Standard Reference. 2006 Release 19. <http://www.nal.usda.gov/fnic/foodcomp>

WPLYW METODY NAWOŻENIA AZOTEM
NA PLONOWANIE I SKŁAD CHEMICZNY OWOCÓW DYNII
(*CUCURBITA MAXIMA*) PRZED I PO PRZECHOWYWANIU

Streszczenie

W doświadczeniu polowym dwie odmiany dyni olbrzymiej (Amazonka, Karowita) nawożono dawką $200 \text{ kg N} \cdot \text{ha}^{-1}$ w następujący sposób: 1 - $100 \text{ kg N} \cdot \text{ha}^{-1}$ przedwegetacyjnie na całą powierzchnię + $100 \text{ kg N} \cdot \text{ha}^{-1}$ pogłównie w postaci 4 oprysków dolistnych, 2 - $100 \text{ kg N} \cdot \text{ha}^{-1}$ miejscowo w pasy o szerokości 50 cm + $100 \text{ kg N} \cdot \text{ha}^{-1}$ pogłównie na całą powierzchnię, 3 - $200 \text{ kg N} \cdot \text{ha}^{-1}$ gniazdowo 25 cm od rośliny na głębokość 10 cm, 4 - w pasy o szerokości 50 cm obornik w dawce $40 \text{ t} \cdot \text{ha}^{-1}$. Oceniano wielkość plonu ogólnego i handlowego oraz skład chemiczny owoców przed i po przechowywaniu przez 90 dni w temperaturze 12°C przy wilgotności względnej powietrza 75%. Tradycyjne wnoszenie azotu na całą powierzchnię pola pozwoliło na uzyskanie istotnie większego plonu niż przy pasowym lub gniazdowym użyciu tego składnika. Owoce dyni nawożonej przedwegetacyjnie w sposób pasowy zawierały najwięcej witaminy C, charakteryzowały się również wysoką zawartością cukrów redukujących i ogółem oraz karotenoidów. Owoce bezpośrednio po zbiorze posiadały więcej substancji rozpuszczalnych, suchej masy, karotenoidów, jak również cukrów redukujących ogółem i witaminy C.