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THE EFFECTS OF NITROGEN FERTILIZATION AND STAGE OF FRUIT MATURITY AT HARVEST ON YIELD AND NUTRITIONAL VALUE OF SCALLOP SQUASH

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ABSTRACT

The aim of the field study was to evaluate the response of scallop squash crop to nitrogen fertilization in the case of cultivation for receiving the fruits with 3–6 cm, 6.1–12 cm or >12 cm in diameter. 'Sunny Delight F_1' was grown from seeds and supplied with 60, 120, 180, 120 + 60, 240 or 120 + 60 + 60 kg N·ha^{-1}. Harvest, which started at the end of June or in early July was conducted with frequency of 2 days, 3–4 days or one week intervals, respectively for small, medium, and large size fruits. Results of the study showed that irrespective of the size of harvested fruits, the maximum mean yield of scallop squash for 3 years was assured by application of 240 kg N·ha^{-1}, and similar effect was provided by 120 + 60 kg N·ha^{-1}. Heavy N fertilization was beneficial for the number of fruits setting and early fruit yield, with no change the nutritional value of the crop. Harvest conduced in more advanced stages of fruit maturity increased yields but caused substantial reduction of fruit number from the unit area. Small size fruits with diameter 3–6 cm had the highest nutritional value expressed by the amounts of vitamin C, carotenoids and total polyphenols. Fruits of later stages of maturity contained higher level of total sugar.

Key words: marketable yield, early yield, fruit setting, fruit chemical composition

INTRODUCTION

Scallop squash (*Cucurbita pepo* var. *patissonina* Greb. f. *radiata* Nois.) belongs to Cucurbitaceae family which consists more than 800 species, and is classified as a bush type summer squash. It produces stems with greatly shortened internodes and sets fruits in close succession, which are ready to harvest in about 6 weeks after planting [Desai and Musmade 1998]. In Central European countries it is still a minor crop grown mostly in home gardens. However, there is observed a growing interest to use the fruits in early stages of development for processing, mostly for canning, freezing or dehydration. Small size fruits with diameter 3–6 cm are harvested before the skin begins to harden and does not need to be removed during processing. The other favorable feature of such fruits is high nutritional value expressed by the content of many health promoting compounds such as vitamins, minerals and antioxidants, which amounts exceed greatly their level found in those harvested at later stages of development [Gajc-Wolska and Skąpski 1994, Grzeszczuk and Falkowski 2002, 2003, Grzeszczuk 2009]. However, the fruits picked up in advanced phases of development, when receive the diameter about 20 cm, and weight 1.5–2.0 kg can be stored even for the period of 2–3 months [Desai and Musmade 1998, Gajewski and Grzeszczuk 2005], while those in diameter 3–6 cm only for one week [Kołota and Balbierz 2014, Balbierz and Kołota 2015].

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Summer squashes, including scallop, are low in energy value equal to 84 kJ per 100 g edible portion [Desai and Musmade 1998] and have higher nutritional value than cucumber, due to higher amounts of protein, vitamin C and carotenoids [Lorenz and Maynard 1988, Gajc-Wolska and Skąpski 1994]. The other advantage of this vegetable crop is its low tendency to nitrates and heavy metals accumulation [Danilčenko 2000, Grzeszczuk 2003, 2009].

Beside its high nutritional value, the beneficial feature of scallop squash is its moderate soil nutrient and moisture requirement, and better tolerance of low temperature than the other species from Cucurbitaceae family. Little information is available in the literature upon the nutritional requirement of scallop squash. Gill [1979] recommended for the summer squash a dose of 60 kg of nitrogen, 30 kg of phosphorus and 30 kg of potassium in addition to 25–30 t of farmyard manure. Yamaguchi [1983] suggested a fertilizer dose comprising 110 kg N, 40 kg P and 90 kg K per 1 ha. Nitrogen is recommended to use in split dose. Half of total amount should be applied at the time of sowing, while the remaining part as a top dressing at 4–6 leaf stage.

The aim of the study was to evaluate the response of scallop squash to nitrogen fertilization in the case of cultivation for the harvest of fruits in different stages of development.

MATERIAL AND METHODS

A field experiment was conducted in 2011–2013 at Piastów Horticultural Research Station (long. 17°00'E, lat. 51°05'N) on a sandy clay soil with 1.8% organic matter and pH in H_2O 7.3. Soil content of available forms of phosphorus ranged 75–79 mg·dm^{-3}, potassium 150–175 mg·dm^{-3}, calcium 360–430 mg·dm^{-3}, magnesium 39–66 mg·dm^{-3} and mineral nitrogen (NH_4 +N-NO_3) 22–32 mg·dm^{-3}, depending on the year of study. The experiment was established in two factorial design in four replications. Nitrogen rate and time of its application was recognized as the first, while size of harvested fruits as the second factor. The individual plot area was 8 m^2 (1.6 × 5 m), with 10 plants per plot.

Seeds of 'Sunny Delight F$_1$' developed by Seminis Vegetable Seeds Company were sown on 10–15 May at spacing of 0.8 m apart in the rows and 1.0 m between rows, with 3 seed per spot. After emergence the seedlings were thinned to one per spot. Crop management followed the commonly accepted recommendations for this vegetable species.

Scallop squash (*Cucurbita pepo* var. *patissonina* Greb. f. *radiata* Nois.) was grown at standard level of phosphorus and potassium available forms – 80 mg P and 200 mg K per 1dm^3 of the soil. The required doses of these nutrients were established upon the annual chemical analysis of soil samples and supplied in the form of triple superphosphate and potassium sulphate at the time of soil preparation for seed sowing. Nitrogen was applied at different rates as preplant fertilization or in split dose with one or two top dressings (60, 120, 180, 120 + 60, 240, 120 + 60 + 60 kg N per 1 ha). The first top dressing dose was supplied broadcast at the stage of 3–4 leaves and the second one at the beginning of florescence and washed down by sprinkler irrigation. In all cases ammonium nitrate was used as the source of nitrogen. Well prepared soil was covered by black agrotextile weighting 30 g per 1 m^2 for weed control.

Fruit harvest started 28th of June in 2011, and 5th and 2nd of July in the subsequent years and lasted till 5–10 of September. During harvest the fruits at different stages of development with horizontal diameter 3–6 cm, 6.1–12.0 cm and >12 cm were picked up from different treatments in 2 days, 3–4 days or one week intervals, respectively. Fruits harvested up to 15 of July were recognized as an early yield.

At the time of maximum fruit setting and development (end of July) the samples of 12 fruits from each plot were collected for chemical analysis. There were evaluated the contents of dry matter (drying at 105°C to the constant weight), total sugars (Luff--Schoorl method), vitamin C (Tillmans method) carotenoids (spectrophotometric method) according to Rumińska et al. [1995], total polyphenols (Folin--Ciocalateu method) according to Slinghard and Singleton [1977]. Data comprising yield and nutrient compounds shown as means for 3 year's study were subjected to statistical evaluation on the basic of analysis of variance for two factorial design. The least significant differences were calculated by the Tukey test at α = 0.05.

RESULTS AND DISCUSSION

Thermal conditions in particular years of the field study showed rather small variation (tab. 1) with mean diurnal temperature for the whole period of plant growth within 17.2°C and 17.5°C. Much higher differences were observed in monthly sums of rainfall in 2011–2013 and their distribution in the subsequent years, which substantially affected the scallop squash yield. Deficiency of water which occurred at the time of seed sowing and early stage of plant growth in 2012 appeared to be detrimental for the yield production, while the highest sum of rainfall in 2013 resulted in the best yielding of this vegetable crop. This effect was especially pronounced in treatment where fruits with diameter 3.0–6.0 cm and 6.1–12 cm were collected.

Marketable yield of scallop squash fruits was significantly affected by nitrogen as well as their stage of development during harvest (tab. 2). Irrespective of the size of harvested fruits in all years of the study the most efficient was the preplant application of 240 kg N·ha^{-1}. Moreover, in low soil moisture content split application of 180 kg N·ha^{-1} or 240 kg N·ha^{-1} produced significantly lower yields that the same quantity of nutrient used in one preplant dose. Split application of nitrogen in the other years was beneficial for the crop yield, and in treatment with 120 + 60 kg N·ha^{-1} proved by statistical evaluation. This is in agreement with the other study where split application of ammonium nitrate as well as Entec 26 did not improve the yield volume of white head cabbage [Chohura and Kołota 2014]. Beneficial effect of such N application using conventional form of fertilizer or that one with nitrification inhibitor may be expected mainly on light soil and at the sites with high precipitation rate or intense irrigation [Pasda et al. 2001], and this was not a case in the trial in 2012.

Mean data for the three years of the study indicate that irrespective of the size of collected fruits, the most efficient was the application of 240 kg N·ha^{-1}, both in single pre-plant or split dose with two top dressings supplied at the time after emergence and at the beginning of flowering. Lower, but not significantly different marketable yield of fruits was received by the use of 120 + 60 kg N·ha^{-1} These results are generally in agreement with those obtained in zucchini, which growth and fruiting was the best when 240 kg N·ha^{-1} was applied, with half of the dose before seed sowing and the remaining part in two top dressings [Słociak and Kołota 2002].

Much more pronounced and quite similar in subsequent years were the differences in yield of scallop squash depending on the size of harvested fruits. The mean yield of small size fruits with diameter 3–6 cm was 3.2 and 4.7 times lower than those of 6.1–12.0 cm and >12 cm, respectively. Similar relations were observed by Mazurek and Niemrowicz-Szczyt [1992] and Grzeszczuk [2009] with scallop

Table 1. Mean air temperature and sums of rainfall during the period of scallop squash cultivation in 2011–2013

Months	Air temperature			Sum of rainfall		
	2011	2012	2013	2011	2012	2013
May	14.8	15.8	14.3	51.4	20.5	57.5
June	19.1	17.2	17.1	61.9	77.1	86.2
July	18.3	20.1	20.0	103.2	70.8	28.3
August	19.4	19.8	21.0	22.7	48.4	37.0
September	15.9	14.8	13.8	21.8	45.0	93.0
Mean/sum after the whole period of cultivation	17.5	17.5	17.2	261.0	261.8	302.0

Table 2. Marketable yield of scallop squash as affected by nitrogen fertilization and stage of fruit development in 2011–2013 ($t \cdot ha^{-1}$)

Nitrogen rate ($kg \cdot ha^{-1}$)	2011				2012				2013				Mean			
	Fruit diameter (cm)				Fruit diameter (cm)				Fruit diameter (cm)				Fruit diameter (cm)			
	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**
60	11.80	36.34	61.23	**36.46**	10.45	34.40	58.94	**34.59**	12.70	49.76	65.75	**42.74**	11.65	40.17	61.97	**37.93**
120	16.19	56.65	73.42	**48.75**	13.50	35.45	59.13	**36.03**	15.97	64.24	55.17	**45.13**	15.22	52.12	62.57	**43.30**
180	20.98	57.38	77.29	**51.89**	13.73	34.00	87.98	**46.90**	21.21	68.63	88.36	**59.40**	18.64	53.34	84.54	**52.17**
120 + 60	21.73	71.13	88.83	**60.56**	11.29	39.92	69.98	**40.40**	21.21	85.84	110.97	**72.67**	18.08	65.63	89.93	**57.88**
240	26.70	71.90	89.08	**62.56**	14.85	47.19	104.90	**55.65**	25.02	78.47	100.70	**68.06**	22.19	65.85	98.23	**62.09**
120 + 60 + 60	24.33	73.04	100.52	**65.96**	11.73	36.50	96.08	**48.10**	26.97	85.35	111.97	**74.76**	21.01	64.96	102.86	**62.94**
Mean	**20.29**	**61.07**	**81.73**	**54.36**	**12.59**	**37.91**	**79.50**	**43.33**	**20.51**	**72.05**	**88.82**	**60.46**	**17.80**	**57.01**	**83.35**	**52.72**
LSD α = 0.05	for:	nitrogen rate		5.45				5.60				7.45				7.52
		size of fruit		2.85				2.15				4.10				4.56
		interaction		n.s.				n.s.				3.25				n.s.

Table 3. Number of fruits in marketable yield of scallop squash as affected by nitrogen fertlization and stage of fruit development in 2011–2013 ($thous \cdot ha^{-1}$)

Nitrogen rate ($kg \cdot ha^{-1)}$)	2011				2012				2013				Mean			
	Fruit diameter (cm)				Fruit diameter (cm)				Fruit diameter (cm)				Fruit diameter (cm)			
	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**
60	470.00	278.75	113.33	**287.36**	690.83	340.00	178.33	**403.06**	630.45	332.08	154.31	**372.28**	630.45	332.08	154.31	**372.28**
120	742.08	397.5	161.25	**433.61**	717.08	364.17	152.92	**411.39**	749.31	420.14	147.22	**438.89**	749.31	420.14	147.22	**438.89**
180	781.67	399.17	161.25	**447.36**	798.33	374.58	192.08	**455.00**	971.11	444.31	185.42	**533.61**	971.11	444.31	185.42	**533.61**
120 + 60	901.67	461.67	180.83	**514.72**	662.92	314.17	247.08	**408.06**	930.97	487.78	227.36	**548.70**	930.97	487.78	227.36	**548.70**
240	1005.0	475.42	182.08	**554.17**	822.92	492.5	229.58	**515.00**	966.11	533.33	212.22	**570.56**	966.11	533.33	212.22	**570.56**
120 + 60 + 60	928.33	518.33	210.00	**552.22**	702.92	382.92	200.42	**428.75**	1062.92	537.08	220.69	**606.90**	1062.92	537.08	220.69	**606.90**
Mean	**804.79**	**421.81**	**168.13**	**464.91**	**732.5**	**378.06**	**200.07**	**436.88**	**885.14**	**459.12**	**191.20**	**511.82**	**885.14**	**459.12**	**191.20**	**511.82**
LSD α = 0.05	for:	nitrogen rate		69.24				n.s.				77.53				53.55
		size of fruit		48.96				36.33				48.97				34.36
		interaction		38.45				27.13				23.45				37.11

Table 4. Early yield of scallop squash as affected by nitrogen fertilization and stage of fruit development in 2011-2013 ($t \cdot ha^{-1}$)

Nitrogen rate ($kg \cdot ha^{-1}$)	2011				2012				2013				Mean			
	Fruit diameter (cm)				Fruit diameter (cm)				Fruit diameter (cm)				Fruit diameter (cm)			
	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**
60	1.96	4.69	5.79	**4.15**	1.65	5.05	8.06	**4.92**	1.95	7.10	8.3	**5.79**	1.85	5.61	7.38	**4.95**
120	2.18	8.46	10.41	**7.02**	2.08	5.30	8.64	**5.34**	2.25	8.85	8.08	**6.39**	2.17	7.54	9.04	**6.25**
180	3.17	10.00	12.4	**8.52**	2.75	5.78	17.18	**8.57**	4.56	7.63	13.34	**8.51**	3.49	7.80	14.3	**8.53**
120 + 60	3.48	16.43	20.37	**13.43**	2.63	9.71	18.67	**10.34**	5.65	16.37	21.56	**14.53**	3.92	14.17	20.2	**12.76**
240	11.06	25.89	30.84	**22.6**	5.48	15.63	35.7	**18.94**	8.04	24.59	31.04	**21.23**	8.19	22.04	32.53	**20.92**
120 + 60 + 60	9.21	25.01	34.96	**23.06**	4.85	10.6	30.6	**15.35**	9.72	26.86	34.15	**23.58**	7.93	20.82	33.24	**20.66**
Mean	**5.18**	**15.08**	**19.13**	**13.13**	**3.24**	**8.68**	**19.81**	**10.58**	**5.36**	**15.23**	**19.41**	**13.34**	**4.59**	**13.00**	**19.45**	**12.35**
LSD α = 0.05	for: nitrogen rate			0.95				1.27				1.23				0.75
	size of fruit			1.51				0.61				1.19				1.17
	interaction			n.s.				n.s.				n.s.				n.s.

Table 5. Dry matter content in scallop squash as affected by nitrogen fertilization and stage of fruit development in 2011–2013 (%)

Nitrogen rate ($kg \cdot ha^{-1}$)	2011				2012				2013				Mean			
	Fruit diameter (cm)				Fruit diameter (cm)				Fruit diameter (cm)				Fruit diameter (cm)			
	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**
60	6.60	5.40	4.64	**5.54**	7.65	6.56	5.64	**6.62**	6.66	4.47	4.74	**5.29**	6.97	5.48	5.01	**5.82**
120	6.37	5.52	4.46	**5.45**	7.30	7.11	5.89	**6.77**	6.55	4.69	4.50	**5.25**	6.74	5.77	4.95	**5.82**
180	6.46	5.11	5.12	**5.56**	7.81	6.99	5.67	**6.83**	6.76	4.75	4.54	**5.35**	7.01	5.62	5.11	**5.91**
120 + 60	6.52	5.38	4.81	**5.57**	7.87	7.29	5.08	**6.75**	6.71	4.87	4.59	**5.39**	7.03	5.85	4.83	**5.90**
240	6.29	5.27	4.28	**5.28**	8.66	7.20	6.18	**7.35**	6.55	5.27	5.3	**5.71**	7.17	5.91	5.25	**6.11**
120 + 60 + 60	6.33	5.27	4.68	**5.42**	7.87	6.73	5.65	**6.75**	7.14	5.36	5.07	**5.86**	7.11	5.79	5.13	**6.01**
Mean	**6.43**	**5.32**	**4.66**	**5.47**	**7.86**	**7.03**	**5.69**	**6.86**	**6.73**	**4.90**	**4.79**	**5.47**	**7.01**	**5.74**	**5.05**	**5.93**
LSD α = 0.05	for: nitrogen rate			n.s.				n.s.				n.s.				n.s.
	size of fruit			0.25				0.44				0.17				0.17
	interaction			n.s.				n.s.				n.s.				n.s.

squash, and Kmiecik [1986], Gajc and Skąpski [1991], Orłowski and Jadczak [2000], Kołota and Słociak [2006] with zucchini.

The yield increment caused by heavy N application can be explained by the substantial enhancement of fruit number collected per unit area which was proved by statistical evaluation in two out of three years of trial (tab. 3). Total fruit number per hectare as the mean for 3 years increased from 372.28 thousands at the rate of 60 kg N·ha^{-1} to 570.56 and 606.90 thousands in treatments with single and split dose of 240 kg N·ha^{-1}.

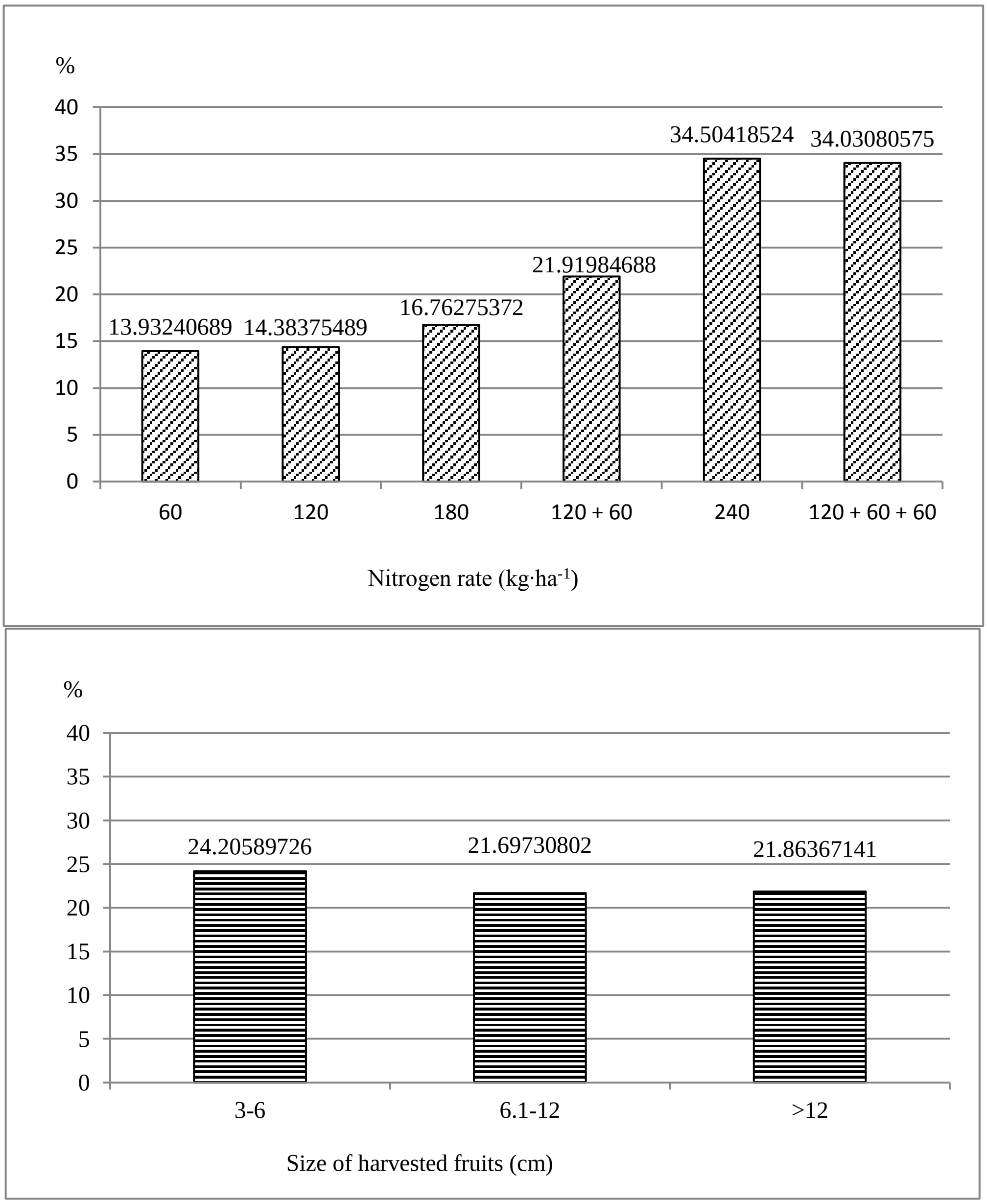

Fig. 1. Percentage of early yield of fruits in marketable yield of scallop squash

Table 6. Vitamin C content in scallop squash as affected by nitrogen fertilization an stage of fruit development in 2011–2013 (mg · 100 g^{-1} f.w.)

Nitrogen rate (kg·ha^{-1})	2011				2012				2013				Mean			
	Fruit diameter (cm)				Fruit diameter (cm)				Fruit diameter (cm)				Fruit diameter (cm)			
	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**	3–6	6.1–2	>12	**Mean**
60	37.03	16.84	18.07	**23.98**	32.88	28.05	18.13	**26.35**	26.08	14.11	11.10	**17.10**	32.00	19.66	15.77	**22.48**
120	29.78	24.71	17.46	**23.98**	30.01	30.25	21.52	**27.26**	26.33	14.94	12.66	**17.98**	28.71	23.3	17.21	**23.07**
180	36.02	19.47	17.95	**24.48**	32.47	30.73	21.81	**28.34**	23.99	12.31	11.57	**15.96**	30.83	20.84	17.11	**22.93**
120 + 60	37.49	20.96	18.9	**25.78**	31.00	27.24	21.27	**26.50**	25.31	18.35	12.92	**18.86**	31.27	22.18	17.70	**23.71**
240	37.96	17.95	19.65	**25.19**	31.88	28.18	20.37	**26.81**	27.47	15.32	12.20	**18.33**	32.44	20.48	17.41	**23.44**
120 + 60 + 60	36.76	24.67	19.05	**26.83**	30.89	27.71	21.36	**26.65**	24.66	17.36	12.27	**18.09**	30.77	23.24	17.56	**23.86**
Mean	**35.84**	**20.77**	**18.51**	**25.04**	**31.52**	**28.69**	**20.74**	**26.99**	**25.64**	**15.4**	**12.12**	**17.72**	**31.00**	**21.62**	**17.13**	**23.25**
LSD α = 0.05	for:	nitrogen rate		n.s.				n.s.				n.s.				n.s.
		size of fruit		3.14				1.52				1.67				1.36
		interaction		n.s.				n.s.				n.s.				n.s.

Table 7. Total carotenoids content in scallap squash as affected by nitrogen fertilization and stage of fruit denelopmentin 2011-2013 (mg ·100 g^{-1} d.w.)

Nitrogen rate (kg·ha^{-1})	2011				2012				2013				Mean			
	Fruit diameter (cm)				Fruit diameter (cm)				Fruit diameter (cm)				Fruit diameter (cm)			
	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**
60	0.62	0.44	0.42	**0.49**	0.64	0.42	0.37	**0.48**	0.71	0.59	0.36	**0.55**	0.66	0.48	0.38	**0.51**
120	0.40	0.47	0.31	**0.39**	0.58	0.49	0.25	**0.44**	0.77	0.70	0.43	**0.63**	0.58	0.56	0.33	**0.49**
180	0.53	0.40	0.31	**0.41**	0.53	0.37	0.18	**0.36**	0.74	0.53	0.50	**0.59**	0.60	0.43	0.33	**0.46**
120 + 60	0.35	0.30	0.34	**0.33**	0.42	0.33	0.26	**0.34**	0.78	0.50	0.46	**0.58**	0.52	0.38	0.35	**0.42**
240	0.48	0.53	0.44	**0.48**	0.49	0.38	0.26	**0.38**	0.53	0.41	0.40	**0.45**	0.50	0.44	0.37	**0.44**
120 + 60 + 60	0.40	0.33	0.24	**0.33**	0.59	0.52	0.31	**0.47**	0.66	0.47	0.41	**0.51**	0.55	0.44	0.32	**0.44**
Mean	**0.47**	**0.41**	**0.34**	**0.41**	**0.54**	**0.42**	**0.27**	**0.41**	**0.70**	**0.54**	**0.43**	**0.55**	**0.57**	**0.45**	**0.35**	**0.46**
LSD α = 0.05	for:	nitrogen rate		0.10				n.s.				n.s.				n.s.
		size of fruit		0.07				0.09				0.09				0.05
		interaction		n.s.				n.s.				n.s.				n.s.

Table 8. Total polyphenols content in scallap squash as affected by nitrogen fertilization and stage of fruit denelopmentin 2011–2013 (mg ·100 g^{-1} f.w.)

Nitrogen rate ($kg \cdot ha^{-1}$)	2011				2012				2013				Mean			
	Fruit diameter (cm)				Fruit diameter (cm)				Fruit diameter (cm)				Fruit diameter (cm)			
	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**
60	35.21	18.25	11.31	**21.59**	48.20	23.42	6.61	**26.08**	24.41	17.61	7.08	**16.36**	35.94	19.76	8.33	**21.34**
120	34.71	19.63	11.75	**22.03**	45.12	27.05	4.93	**25.70**	26.04	20.01	9.62	**18.56**	35.29	22.23	8.77	**22.10**
180	38.83	17.60	13.04	**23.16**	43.11	23.37	5.93	**24.14**	22.63	18.33	13.09	**18.02**	34.86	19.77	10.69	**21.77**
120 + 60	35.41	20.88	13.31	**23.20**	52.69	24.86	7.47	**28.34**	24.51	22.43	9.72	**18.89**	37.53	22.72	10.17	**23.48**
240	36.56	23.01	11.81	**23.79**	41.85	25.91	6.64	**24.80**	31.05	22.49	12.95	**22.16**	36.48	23.80	10.47	**23.59**
120 + 60 + 60	38.65	20.81	10.20	**23.22**	46.68	19.14	4.38	**23.40**	36.67	22.22	15.47	**24.79**	40.67	20.73	10.02	**23.80**
Mean	**36.56**	**20.03**	**11.90**	**22.83**	**46.27**	**23.96**	**5.99**	**25.41**	**27.55**	**20.51**	**11.32**	**19.80**	**36.80**	**21.50**	**9.74**	**22.68**
LSD α = 0.05	for:	nitrogen rate		n.s.				n.s.				2.46				1.87
		size of fruit		2.47				2.35				1.74				1.23
		interaction		n.s.				n.s.				1.26				n.s.

Table 9. Total sugar content in scallap squash as affected by nitrogen fertilization and stage of fruit denelopmentin 2011-2013 (% f.w.)

Nitrogen rate ($kg \cdot ha^{-1}$)	2011				2012				2013				Mean			
	Fruit diameter (cm)				Fruit diameter (cm)				Fruit diameter (cm)				Fruit diameter (cm)			
	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**	3–6	6.1–12	>12	**Mean**
60	1.48	1.79	1.59	**1.62**	2.06	1.88	2.28	**2.07**	1.11	1.44	1.20	**1.25**	1.55	1.70	1.69	**1.65**
120	1.39	1.71	1.47	**1.53**	1.69	1.87	1.83	**1.80**	1.45	1.53	1.78	**1.59**	1.51	1.70	1.70	**1.64**
180	1.37	1.65	1.41	**1.48**	1.81	1.83	2.21	**1.95**	1.55	1.60	1.31	**1.49**	1.58	1.69	1.65	**1.64**
120 + 60	1.57	1.95	1.78	**1.76**	1.89	2.11	2.00	**2.00**	1.69	1.30	1.76	**1.58**	1.71	1.78	1.85	**1.78**
240	1.42	1.85	1.55	**1.61**	1.60	1.90	2.03	**1.85**	1.48	1.59	1.15	**1.41**	1.71	1.78	1.85	**1.78**
120 + 60 + 60	1.30	1.81	1.53	**1.55**	1.69	1.81	1.93	**1.81**	1.60	1.47	2.07	**1.71**	1.53	1.69	1.84	**1.69**
Mean	**1.42**	**1.79**	**1.55**	**1.59**	**1.79**	**1.90**	**2.05**	**1.91**	**1.48**	**1.49**	**1.55**	**1.51**	**1.6**	**1.73**	**1.76**	**1.70**
LSD α = 0.05	for:	nitrogen rate		n.s.				n.s.				n.s.				n.s.
		size of fruit		0.16				0.11				n.s.				0.09
		interaction		n.s.				n.s.				n.s.				n.s.

Interaction between both investigated factors occurred only in 2013, when the enhancement N dose over 180 kg N·ha^{-1} as well as split its application did not produce significantly higher yield of fruits with diameter 3–6 cm. For the other fruits categories the most efficient was the dose equal to 240 kg N·ha^{-1}, with beneficial effect of split N dose use.

Developing fruits tend to suppress subsequent pistillate flowering and cause a decrease in their number per unit area [Rubatzky and Yamaguchi 1997, Orłowski and Jadczak 2000, Kołota and Słociak 2006]. As a result of this, the number of fruits decreased from 885.14 to 191.20 thousands per hectare along with the delayed stage of development at harvest. Similar to yield production, the split application of high nitrogen doses did not significantly affect the number of set fruits in plants if compared to the same amounts of this nutrient supplied in the pre-plant dose. Interaction of the tested factors indicate that the number of set fruits with diameter >12 cm was much less dependent on N rate if compared to the smaller ones.

Early yield of fruits collected to the half of July was highly and quite similar in particular years affected by the rate of nitrogen applied (tab. 4). Increment its dose from 60 to 240 kg N·ha^{-1} was favorable for this yield category in all evaluated classes of fruits. Irrespective of the size of harvested fruits, it caused the early yield enhancement for the whole period of the study from 4.95 t·ha^{-1} to 20.92 t·ha^{-1}, and its percentage in marketable yield from 13.1% to 33.7% (fig. 1). Variable effects were observed under influence of timing the nitrogen nutrition. Split application the dose of 180 kg N·ha^{-1} was beneficial for the early yield of fruits with diameter 6.1–12 cm and >12 cm, while not significant differences were found in efficiency of the single and split dose of 240 kg N·ha^{-1}. Percentage of early yield in marketable yield depending particular fruit size was a subject of only slight variation ranging within 22% and 26%. No interaction was found between tested factors and size of early yield to scallop squash.

Obtained date did not confirm the statement of Słociak and Kołota [2002] with zucchini indicating no relations between N rate and early yield of fruit as well as report of Komosa et al. [2012] about the disadvantageous effect of this nutrient on earliness of fruit vegetable crops.

Dry matter content tend to increase along with the enhancement of N dose. However, in the obtained data were not in most cases proved statistically (tab. 5). Like to the previous study with zucchini [Kołota and Słociak 2006], nitrogen fertilization did not affect the content of total sugars and vitamin C, irrespective of fruit size of scallop squash at harvest (tab. 6–7). The only pronounced changes in nutritional value of scallop squash under influence of heavy N application was the non statistical drop of carotenoids content in fruits (tab. 8) and the enhancement of total polyphenols (tab. 9).

Similar to the data presented in the literature with different vegetable crop species such as leek, kohlrabi, zucchini, pea, eggplant and sweet pepper [Lee et al. 1982, Kader 1988, Słociak and Kołota 2002, Gajewski and Arasimowicz 2006, Lester 2006, Biesiada et al. 2007, Grzeszczuk 2009, Kołton et al. 2011] the important factor influencing the nutritional value of scallop squash was the stage of fruit maturity at the time of harvest. Small size fruits with diameter 3–6 cm, preferred for the food industry, being also in high demand for the fresh market appeared to be a rich source of valuable phytonutrients for human being. They contained significantly higher amounts of dry matter, total sugars, vitamin C and total polyphenols if compared to those with 6.1–12 cm and >12 cm in diameter. Especially high decrement along with the delayed stage of maturity was observed in the case of vitamin C, carotenoids and total polyphenols. Vitamin C and polyphenols amounts in small size fruits was nearly two time higher than in those with diameter >12 cm, and in the case of polyphenols even four times higher. Similar relations between size of harvested fruits and contents of these phytonutrients in scallop squash was observed by Grzeszczuk [2009], and in zucchini by Kołota and Słociak [2006]. In the other vegetable crops there were observed variable effects of this factor on vitamin C and carotenoids content. This discrepancy between different vegetable crops may be due to differences in growth habit and growing conditions.

CONCLUSIONS

Data of field study revealed that the maximum marketable fruit yield of scallop squash was assured by application of 240 kg N·ha^{-1}, and almost similar by the use of split dose 120 + 60 kg N·ha^{-1}. Heavy N fertilization was beneficial for the number of fruit setting and early fruit yield, with generally no effect on nutritional value of the crop. The only exception was its adverse effect on carotenoids content and enhancement of total polyphenols.

Harvest conducted in advanced stages of growth significantly increased yields, but was associated with considerable reduction of fruit number from the unit area. Small size fruits contained higher amounts of vitamin C, carotenoids and polyphenols, while lower level of total sugars if compared to harvested in later stages of maturity. Delicate skin, which does not need to be removed, combined with high nutritional value make such fruits as the most suitable for processing purpose.

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