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Effect of plastic covering and nitrogen fertilization on yield and quality of early potatoes

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ABSTRACT

The effect of agrotextile covering and the nitrogen fertilization (0, 30, 60, 90 kg N ha^{-1}) on the yield and tuber quality of very early potato cultivars ('Aster', 'Drop') was investigated. The potatoes were harvested 60 days after planting. In the year with cold spring, the agrotextile covering allowed to obtain the tuber yield 2-times higher, than that without covering, but in the years with warmer springs the covering effectiveness was not substantial. The covering caused higher increase in tuber yield of 'Aster'. The covering resulted in an increase of the dry matter content in tubers by 1.29% and starch by 0.45%. The nitrogen fertilization had no effect on the yield and quality of potato tubers.

INTRODUCTION

Very good thermal conditions for the production of potatoes for an early crop occur in Poland approximately every third year. Unfavourable effect of low temperatures in the first period of potato vegetation may be alleviated with the use of agrotextile covering (Prośba-Białczyk and Mydlarski 1998, Pszczółkowski and Sawicka 1999, Rekowska et al. 1999). The forcing of potato vegetation by covering can affect the tuber quality (Friessleben 1984, Prośba-Białczyk and Mydlarski 1998, Sawicka and Mikos-Bielak 2000, Lachman et al. 2003). Among agronomical factors affecting the yield and quality of early potato is the nitrogen fertilization (Roztropowicz 1989, Leszczyński 1994, Wierzejska-Bujakowska 1996, Sawicka 1998).

The aim of the study was to estimate the effect of the agrotextile covering and different doses of nitrogen on the yield and tuber quality of early potatoes in the middle-east of Poland.

MATERIAL AND METHODS

The effect of potato covering with agrotextile (Pegas Agro 17 from planting to the plant height of 15 cm) and the level of nitrogen fertilization (0, 30, 60, and 90 kg N ha^{-1} as ammonium nitre at the constant phosphorus and potassium fertilization – on the levels 90 kg P_2O_5 ha^{-1} as double superphosphate and 120 kg K_2O ha^{-1} as potash salt 60%) on the yield and quality of very early potato cultivars (‘Aster’ and ‘Drop’) was investigated.

The experiments were carried out in 2000 – 2002, on brown soil, pH 6.0-6.7, with the nutrient levels as follows: 2.3-2.5 mg N (NO_3+NH_4), 9.3-10.7 mg P_2O_5, 9.2-9.8 mg K_2O, and 2.7-3.9 mg Mg in 100 g of the soil. The field experiment was set in split-block-split-plot design in three replications. The plot area was 15 m^2. Manure at the rate of 30 t ha^{-1} was applied in autumn and mineral fertilizers during the spring tillage. In the consecutive years of the study the 6-week pre-sprouted potato tubers were planted on April 12, 11, and 9, at the spacing of 62.5 × 30 cm, and harvested 60 days later. The total and marketable yields of tubers (diameter above 30 mm) were estimated. 50 tubers of different size of each treatment were taken for laboratory analyses. The dry matter, starch (using the polarimetric method), total protein (using the Kjeldahl method) and vitamin C (using the Pijanowski method) content in potato tubers were estimated.

The results of the experiment were analysed statistically by means of the analysis of variance. The significance of differences was verified using Tukey’s test at $p = 0.05$.

During the study, in 2000 and 2002 the thermal conditions were favourable for the potato cultivation for an early crop. In 2001 the second 10 days of April were very cold. A drop of temperature was observed in the second 10 days of May, too. In 2000 and 2001 a shortage of rainfallas, particulary in May, was recorded (Table 1).

Table 1. Mean air temperature and precipitation totals in the vegetation period of potato

Year	Temperature [°C]			Precipitation [mm]		
	April	May	June	April	May	June
2000	12.9	16.5	19.6	47.5	24.6	17.0
2001	8.7	15.5	17.1	69.8	28.0	36.0
2002	9.0	17.0	17.2	12.9	51.3	61.1
Mean 1981 – 1995	7.7	10.0	16.1	52.3	50.0	68.2

RESULTS AND DISCUSSION

The agrotextile covering caused significant increase in the tuber yield. During the three-year period of the study, the total tuber yield was higher on average by 2.18 t ha^{-1} (23.6%) and the marketable tuber yield by 2.40 t ha^{-1} (30.1%) than that in the cultivation without plant covering (Table 2). In other studies (Prośba-Białczyk and Mydlarski 1998, Rekowska et al. 1999) the use of agrotextile covers increased the yield of marketable tubers obtained after 60 days from planting by 27% and 70% on average in the Szczecin and Wrocław regions, respectively. Higher increase of the tuber yield as a result of covering was obtained in the years with cool springs (Pszczółkowski and Sawicka 1999), which was confirmed by the present study. The largest increase of the tuber yield by agrotextile covers was obtained in 2001, with the lowest average temperature in April and May. In this year, the increase in the total yield as a result of covering amounted to 6.88 t ha^{-1} (153.6%) and marketable yield to 7.03 t ha^{-1} (205.9%). The slight and non-statistically confirmed difference in the tuber yield of potato cultivated with and without covering were observed in 2000 and 2002, with the warmer springs (Table 2).

The forcing of plants vegetation as a result of agrotextile covering caused the increase in dry matter and starch content in tubers on average by 1.29% and 0.45%, respectively (Table 3). More favourable effect of agrotextile covering on the increase of dry matter content in tubers was found in 2000, with the lowest rainfalls during the potato vegetation. However, the starch content, increased in 2002, a very warm and wet year. No significant differences between dry matter and starch contents in potato tubers cultivated under the agrotextile and with the use of the traditional method were proved by Prośba-Białczyk and Mydlarski

(1998). Higher dry matter and starch content in potato tubers cultivated under the polyethylene sheet were stated by other authors (Friessleben 1984, Sawicka and Mikos-Bielak 2000). In the present study there was a slight and non-statistically confirmed tendency to the increase in protein content in potato tubers cultivated under agrotextile. In that method of potato cultivation the lower content of vitamin C in tubers rather than that of the cultivation without plant covering was found (Prośba-Białczyk and Mydlarski 1998, Sawicka and Mikos-Bielak 2000), which was not confirmed in the present study. The potato cultivation method had no significant effect on the vitamin C content in potato tubers. In the study carried out by Lachman et al. (2003), agrotextile plant covering resulted in a tendency to increase the vitamin C content in potato tubers.

Table 2. Effect of agrotextile covering and nitrogen fertilization on the tuber yield of two potato cultivars [t ha^{-1}]

Factor		Total yield			Marketable yield		
		No covering	Agrotextile	Mean	No covering	Agrotextile	Mean
Year	2000	8.20	7.63	7.92	6.59	6.66	6.63
	2001	4.48	11.36	7.92	3.41	10.44	6.93
	2002	15.08	15.29	15.18	13.90	14.01	13.95
Nitrogen dose [kg ha^{-1}]	0	8.94	11.86	10.40	7.61	10.70	9.15
	30	8.91	10.57	9.74	7.66	9.65	8.65
	60	9.78	11.48	10.63	8.70	10.31	9.51
	90	9.37	11.79	10.58	7.90	10.81	9.36
Cultivar	'Aster'	10.14	13.07	11.61	8.81	11.96	10.38
	'Drop'	8.36	9.78	9.07	7.13	8.78	7.95
Mean		9.25	11.43	10.34	7.97	10.37	9.17
$LSD_{0.05}$ for:							
year			2.19			2.12	
covering			1.43			1.38	
year x covering			2.47			2.39	
fertilization			n. s.			n. s.	
cultivar			0.67			0.69	
covering x cultivar			0.94			0.97	

Table 3. Effect of agrotextile covering and nitrogen fertilization on the content of some nutrition compounds in potato tubers

Factor		Dry matter [% f.w.]			Starch [% f.w.]			Protein [% f.w.]			Vitamin C [mg 100 g^{-1} f.w.]		
		No covering	Agrotextile	Mean	No covering	Agrotextile	Mean	No covering	Agrotextile	Mean	No covering	Agrotextile	Mean
Year	2000	18.44	20.36	19.40	11.82	11.74	11.79	1.73	1.85	1.79	10.11	9.80	9.96
	2001	14.56	15.38	14.97	9.53	10.12	9.83	1.36	1.32	1.34	10.16	10.10	10.13
	2002	15.73	16.85	16.29	9.86	10.69	10.28	1.39	1.44	1.42	10.89	10.98	10.94
Nitrogen dose [kg ha^{-1}]	0	16.17	17.10	16.63	10.59	10.66	10.63	1.42	1.42	1.42	10.49	10.17	10.33
	30	16.18	17.44	16.81	10.36	10.94	10.66	1.48	1.50	1.49	10.48	10.30	10.40
	60	16.39	17.80	17.09	10.56	10.54	10.55	1.51	1.58	1.55	10.24	10.30	10.27
	90	16.23	17.78	17.00	10.09	11.26	10.68	1.55	1.64	1.60	10.34	10.40	10.37
Cultivar	'Aster'	16.47	17.80	17.13	10.54	10.87	10.71	1.54	1.59	1.56	10.35	10.29	10.32
	'Drop'	16.02	17.27	16.64	10.27	10.83	10.55	1.44	1.48	1.46	10.42	10.30	10.35
Mean		16.24	17.53	16.89	10.40	10.85	10.63	1.49	1.54	1.52	10.39	10.29	10.34
$LSD_{0.05}$ for:													
year			0.36			0.40			0.12			0.51	
covering			0.23			0.26			n. s.			n. s.	
year x covering			0.40			0.45			n. s.			n. s.	
fertilization			n. s.			n. s.			n. s.			n. s.	
cultivar			0.24			n. s.			0.04			n. s.	

The effect of the nitrogen fertilization on the tuber yield of early potatoes was rather slight and often it could not be noticed at all (Wierzejska-Bujakowska 1996, Sawicka 1998), which was confirmed by the present study. The low nitrogen fertilization efficiency may have resulted from precipitation shortages in the period of potato vegetation. The drought conditions and high temperatures of the vegetation period considerably decreased the nitrogen uptake and hindered its utilization with fertilizers (Lis and Wierzejska-Bujakowska 2000). The study carried out by Sawicka (1998) showed a larger efficiency of the nitrogen fertilization in the cultivation of very early potato covered by a polyethylene sheet than in the cultivation without plant covering, which was not confirmed by the present study.

The nitrogen fertilization in the range of the tested doses did not have any effect on dry matter and starch content in tubers (Table 3). In studies carried out by other authors, a dose of 80 kg N ha^{-1} resulted in the decrease of dry matter and starch content in tubers of 'Aster' and 'Drop' harvested 56-58 days after planting (Prośba-Białczyk and Mydlarski 1998). The application of high doses of nitrogen can cause an increase of total protein content and decrease of vitamin C content in tubers (Roztropowicz 1989, Leszczyński 1994), which was not found in the present study.

The average total and marketable tuber yield of 'Aster' was higher than that of 'Drop' by 2.54 t ha^{-1} (28.0%) and by 2.43 t ha^{-1} (30.6%), respectively (Table 2). The agrotextile covering caused higher increase of tuber yield of 'Aster' than that of 'Drop', which confirmed the observations of Pszczółkowski and Sawicka (1999).

Higher content of dry matter and protein was determined in tubers of 'Aster'. No significant difference in starch and vitamin C content in tubers of both cultivars was found (Table 3).

CONCLUSIONS

1. In the production of very early potato in the middle-east of Poland the choice of appropriate cultivar and the cultivation method was more essential than the nitrogen fertilization.
2. In the year with cold spring, the agrotextile covering allowed to obtain the tuber yield 2-times higher than that without plant covering, however, in the years with the warmer springs the covering effectiveness was not substantial.
3. The forcing of plant vegetation by agrotextile covering caused increase of the dry matter and starch content in tubers, in comparison with the no covering cultivation.
4. The level of nitrogen fertilization did not affect the yield and tuber quality of early potatoes.
5. 'Aster' rather than 'Drop' was more useful for the cultivation of very early crop due to the larger tuber yield and the higher dry matter and protein content.

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WPŁYW OSŁONY I NAWOŻENIA AZOTEM NA PLON I JAKOŚĆ ZIEMNIAKA WCZESNEGO

Streszczenie: Badano wpływ przykrycia agrowłókniną oraz nawożenia azotem (0, 30, 60, 90 kg N ha^{-1}) na plon i jakość bulw bardzo wczesnych odmian ziemniaka (‘Aster’ i ‘Drop’). Ziemniaki zbierano po 60 dniach od sadzenia. W roku o chłodnej wiośnie zastosowanie osłony z agrowłókniny pozwoliło uzyskać dwukrotnie większy plon bulw niż w uprawie bez osłony, natomiast w latach o ciepłej wiośnie skuteczność użycia osłony była niewielka. Stosowanie osłony spowodowało większy wzrost plonu odmiany ‘Aster’. Przyspieszenie wegetacji roślin w wyniku stosowania osłony spowodowało wzrost zawartości suchej masy w bulwach średnio o 1,29%, a skrobi o 0,45%. Nawożenie azotem nie miało wpływu na plon i jakość bulw ziemniaka.

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