

Electronic Journal of Polish Agricultural Universities is the very first Polish scientific journal published exclusively on the Internet, founded on January 1, 1998 by the following agricultural universities and higher schools of agriculture: University of Technology and Agriculture of Bydgoszcz, Agricultural University of Cracow, Agricultural University of Lublin, Agricultural University of Poznan, Higher School of Agriculture and Teacher Training Siedlce, Agricultural University of Szczecin, and Agricultural University of Wroclaw.



**ELECTRONIC
JOURNAL
OF POLISH
AGRICULTURAL
UNIVERSITIES**

**2004
Volume 7
Issue 1
Series
HORTICULTURE**

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WADAS W., JABŁOŃSKA-CEGLAREK R., KOSTERNA E. 2004. THE EFFECT OF THE CULTIVATION METHOD AND
NITROGEN FERTILIZATION ON THE SIZE AND STRUCTURE OF THE YIELD OF IMMATURE POTATO TUBERS **Electronic
Journal of Polish Agricultural Universities**, Horticulture, Volume 7, Issue 1.
Available Online <http://www.ejpau.media.pl>

THE EFFECT OF THE CULTIVATION METHOD AND NITROGEN FERTILIZATION ON THE SIZE AND STRUCTURE OF THE YIELD OF IMMATURE POTATO TUBERS

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ABSTRACT

The effect of the potato cultivation method (no covering, under Pegas Agro 17 agrotexile from planting to the plant height of 15 cm) and the level of nitrogen fertilization (without nitrogen, 30, 60, 90 kg N·ha⁻¹) on the size and structure of the tuber yield of two very early potato cultivars ('Aster', 'Drop') was investigated. The potatoes were harvested after 60 and 75 days from planting.

Agrotexile fibre covering increased the marketable tuber yield after 60 days from planting by 30.11% and after 75 days from planting by 12.74%, compared to the cultivation with no covering. A greater increase in the tuber yield as a result of covering was obtained in the cultivation of the 'Aster' cultivar rather than the 'Drop' cultivar. On average, the portion of large tubers, 40-50 mm and 50 mm in diameter, after 60 days from planting was higher in this method of cultivation by respectively 8.46% and 2.91%, compared to the control treatment. In later date of potato harvest the agrotexile covering did not cause any significant increase in the tuber yield. A better yield structure, i. e. with the greatest portion of large tubers in the yield, was observed for the 'Aster' cultivar. The nitrogen fertilization, within the range of the tested doses, did not have significant effect on the tuber yield and yield structure.

Key words: early potato, agrotexile covers, nitrogen fertilization, tuber yield

INTRODUCTION

The effect of potato cultivation for harvesting early in the season depends on the weather conditions in the initial period of vegetation, especially on the temperature. For the production of very early potato a higher temperature in April and May is essential, because of large risk of the occurrence of spring ground frosts. A profitable yield in the first half of June is possible to obtain when the soil is heated up to 5-6°C at the beginning of April, and an average temperature in May reaches above 14°C. Very good thermal conditions for the potato production of early crop occur in Poland approximately every three years. Simultaneously, very cool Mays with the temperature below 10°C occur every four to six years [1]. The favourable thermal conditions in the initial period of plant vegetation may be secured by the use of covering with perforated polyethylene foil or agrotexile. The use of covers advances the harvest and increases the marketable yield, compared to the cultivation with no plant covering [3, 6, 8, 10, 15, 16, 17, 18, 20, 22].

Yield production, apart from the effect of weather conditions, requires that plants be provided with a suitable amount of nutrients. Nitrogen is the most yield-stimulating component. The nitrogen fertilization of potato is widely discussed in both domestic and foreign literature. Opinions of many authors on optimum nitrogen doses are rather controversial, which points to a large diversity of cultivars with regard their fertilization requirements [2, 4, 12, 13, 14, 19, 21, 23, 24, 25]. Potatoes grown for harvesting early in the season require smaller nitrogen fertilization than potatoes harvested after the end of vegetation. Nitrogen doses in the potato cultivation for early crop should be adjusted to the cultivar, harvest date and the soil-weather conditions of a given region.

The aim of the study was to determine the effect of the agrotexile covering and different nitrogen doses on the yield size and structure of young tubers of very early potato cultivars.

MATERIALS AND METHODS

The research was carried out in south-eastern Poland in the years 2000-2002, on brown soil. The soil was characterised by the mean to high content of available phosphorus and potassium and by the magnesium content ranging from low to medium, pH = 6.0-6.7. A field experiment was conducted in the split-block-split-plot design in three replications. The area of each plots was 15 m².

The effect of a potato cultivation method (no covering, under Pegas Agro 17 agrotexile from planting to the plant height of 15 cm) and the level of nitrogen fertilization (without nitrogen, 30, 60, 90 kg N·ha⁻¹ with the constant phosphorus and potassium fertilization in the amount of 90 kg P₂O₅·ha⁻¹ and 120 kg K₂O·ha⁻¹) on the size and structure of the tuber yield of two very early potato cultivars ('Aster', 'Drop'), was examined.

Potatoes were cultivated in the fields after cereals. Farmacyard manure in the dose of 30 t·ha⁻¹ was applied in autumn, and the mineral fertilizers were used during the spring cultivation of the field. The six-week pre-sprouted potato tubers were planted on 12, 11 and 9 April in the successive years of the research, at the spacing of 62.5×30 cm. The potatoes were harvested after 60 and 75 days from planting. At each date, the total tuber yield and the marketable tuber yield (tubers over 30 mm in diameter) were determined. During the harvest, five-kilo tuber samples were taken from each plot, in order to determine the yield structure, which is the mass fraction in the yield of tubers which were: below 30 mm, 30-40 mm, 40-50 mm, 50-60 mm and over 60 mm in diameter.

The results of the experiment were analysed statistically by means of the variance analysis. The significance of differences was verified using the Tukey's test.

Table 1. Mean air temperatures (°C) and total rainfalls (mm) in the period of potato vegetation according at the Zawady Meteorological Station

Years	Air temperature			Total rainfalls		
	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 of many years 1981-1995	7.7	10.0	16.1	52.3	50.0	68.2

The weather conditions during the research period varied. The most favourable conditions for the potato cultivation for early crop were in the year 2002 (tab. 1). In the year 2000, the first decade of April was very warm and the average air temperature was 19.0°C. However, the temperature dropped at the beginning of May, on average by 3.5°C. In the year 2001, after a very warm first decade of May, with the average air temperature of 18.6°C, a significant drop in temperature was observed, especially in the third decade of this month, when the average air temperature was only 12.4°C. Such temperature distribution limited the growth and development of potato plants. The total precipitation sum during the potato vegetation was sufficient for the proper growth and development of plants, only in the year 2002. Precipitation shortages occurred in the earlier years of studies, especially in May and June.

RESULTS

The weather conditions during the potato vegetation significantly influenced the quantity of obtained yield. The most favourable conditions for the potato cultivation for early harvest were in the very warm year 2002. In this year, the yield of tubers harvested after 60 days from planting was almost twice as high, and after 75 days from planting almost one and a half time as high as in the earlier years (tab. 2, 3).

Table 2. The effect of potato cultivation method on the tubers yield 60 days after planting, t·ha⁻¹

Cultivation method	Cultivar	Total yield				Marketable yield			
		2000	2001	2002	mean	2000	2001	2002	mean
No covering	Aster	8.42	6.20	15.81	10.14	6.95	4.98	14.50	8.81
	Drop	7.98	2.76	14.33	8.36	6.24	1.85	13.31	7.13
	mean	8.20	4.48	15.08	9.25	6.59	3.41	13.90	7.97
Under agrotexile	Aster	8.81	14.58	15.82	13.07	7.75	13.47	14.65	11.96
	Drop	6.46	8.13	14.75	9.78	5.57	7.40	13.37	8.78
	mean	7.63	11.36	15.29	11.43	6.66	10.44	14.01	10.37
Mean for cultivars	Aster	8.62	10.39	15.81	11.61	7.35	9.23	14.57	10.38
	Drop	7.22	5.44	14.54	9.07	5.90	4.63	13.34	7.95
Mean for years		7.92	7.92	15.18	10.34	6.63	6.93	13.95	9.17
NIR _{0.05}									
years		2.19				2.12			
cultivation method		1.43				1.38			
years × cultivation method		2.47				2.39			
cultivar		0.67				0.69			
years × cultivar		1.16				1.19			
cultivation method × cultivar		0.94				0.97			

Table 3. The effect of potato cultivation method on the tubers yield 75 days after planting, t·ha⁻¹

Cultivation method	Cultivar	Total yield				Marketable yield			
		2000	2001	2002	mean	2000	2001	2002	mean
No covering	Aster	13.62	19.29	26.74	19.88	12.50	18.52	26.04	19.02
	Drop	14.87	11.48	29.33	18.56	13.68	10.91	29.02	17.87
	mean	14.25	15.38	28.04	19.22	13.09	14.72	27.53	18.45
Under agrotexile	Aster	16.01	27.08	22.29	21.79	14.98	26.37	21.81	21.05
	Drop	17.18	18.71	27.46	21.12	16.40	18.33	26.89	20.54
	mean	16.60	22.90	24.87	21.46	15.70	22.53	24.35	20.80
Mean for cultivars	Aster	29.63	46.37	49.03	20.84	27.48	44.89	47.85	20.04
	Drop	32.05	30.19	56.79	19.84	30.08	29.24	55.91	19.21
Mean for years		15.42	19.14	26.46	20.34	14.39	18.53	25.94	19.62
NIR _{0.05}									
years		3.09				2.94			
cultivation method		2.01				1.92			
years × cultivation method		3.48				3.32			
years × cultivar		1.86				1.86			

The use of the agrotextile significantly increased the tuber yield, in comparison with the cultivation without plants covering. A higher effect of the cover use was observed at the early date of potato harvest ([tab. 2, 3](#)). In that method of potato cultivation, the total and marketable tuber yield harvested after 60 days from planting was higher, compared to the control treatment, on average by respectively 2.18 t·ha⁻¹ (23.57%) and 2.40 t·ha⁻¹ (30.11%). After two-week delay of potato harvest the difference in the total and marketable tuber yield amounted to respectively 2.24 t·ha⁻¹ (11.65%) and 2.35 t·ha⁻¹ (12.74%). The yield increase as a result of the covering was determined by the weather conditions in the years of studies. The largest effect of the use of agrotextile covers was obtained in the year 2001, with of the lowest temperature in the initial period of potato vegetation. In this year, the use of agrotextile covers resulted in an increased total tuber yield which averaged 6.88 t·ha⁻¹ (153.57%) and marketable tuber yield 7.03 t·ha⁻¹ (206.16%) after 60 days from planting and respectively 7.52 t·ha⁻¹ (48.89%) and 7.81 t·ha⁻¹ (53.06%) after 75 days from planting. There were no significant differences in the tuber yields in the cultivation with and without the agrotextile covering in the years 2000 and 2002, when the springs were warmer ([tab. 2, 3](#)).

The applied nitrogen doses did not have significant effect on the quantity of potato tuber yield at both dates of potato harvest. Only a slight tendency towards increasing the yield with the dose 60 kg N·ha⁻¹ was found, however, the differences were not statistically proved ([tab. 4](#)).

Table 4. The effect of nitrogen fertilization on the yielding of potato, t·ha⁻¹

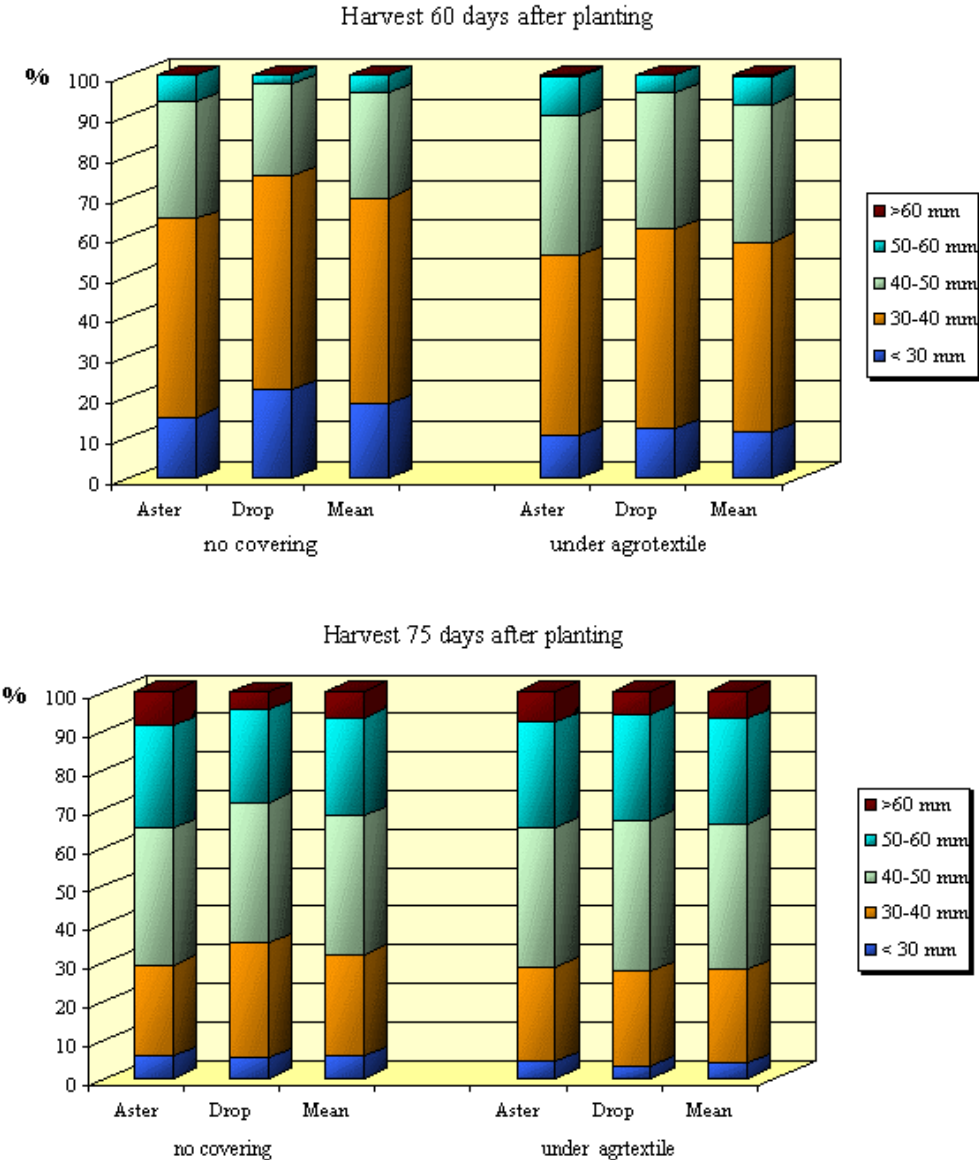
Nitrogen fertilization kg N·ha	Cultivar	Date of harvest			
		60 days after planting		75 days after planting	
		total yield	marketable yield	total yield	marketable yield
0	Aster	11.67	10.31	17.37	16.64
	Drop	9.12	8.00	17.33	16.78
	mean	10.40	9.15	17.35	16.71
30	Aster	10.56	9.44	20.86	20.00
	Drop	8.92	7.87	21.22	20.56
	mean	9.74	8.65	21.04	20.28
60	Aster	12.12	11.01	22.61	21.77
	Drop	9.14	8.01	20.65	19.83
	mean	10.63	9.51	21.62	20.80
90	Aster	12.07	10.77	22.53	21.74
	Drop	9.09	7.94	30.22	19.65
	mean	10.58	9.36	21.34	20.69
Mean for cultivars	Aster	11.61	10.38	20.84	20.04
	Drop	9.07	7.95	19.84	19.21
Mean for years		10.34	9.17	20.34	19.62
NIR _{0.05}		n. s.	n. s.	n. s.	n. s.

Higher yields were obtained in the case of the ‘Aster’ cultivar rather than the ‘Drop’ cultivar at both dates of harvest. The total and marketable tuber yields of the ‘Aster’ cultivar harvested after 60 days from planting, were higher by respectively 2.54 t·ha⁻¹ (28.00%) and 2.43 t·ha⁻¹ (30.57%), in the three-year period of study. The differences in the yields of both cultivars were smaller and statistically insignificant at the later date of potato harvest ([tab. 2, 3](#)). The greatest differences in the yields of both cultivars were found in the year 2001 which was rather unfavourable for the cultivation of early potato. In this year, the yield of the ‘Aster’ cultivar was nearly twice as high after 60 days from planting and one and a half time as high after 75 days from planting as that of the ‘Drop’ cultivar.

The use of the agrotextile covering increased the tuber yield of the ‘Aster’ cultivar rather than that of the ‘Drop’ cultivar, especially at the very early date of harvest ([tab. 2, 3](#)). In that method of potato cultivation, the total tuber yields of the ‘Aster’ and ‘Drop’ cultivar which, after 60 days from planting, were higher on average by respectively 2.93 t·ha⁻¹ (28.90%) and 1.42 t·ha⁻¹ (16.98%). The differences in the marketable yield amounted to respectively 3.15 t·ha⁻¹ (35.75%) and 1.65 t·ha⁻¹ (23.14%). At the later date of potato harvest, the interaction of the cultivation method and potato cultivar was not statistically proved.

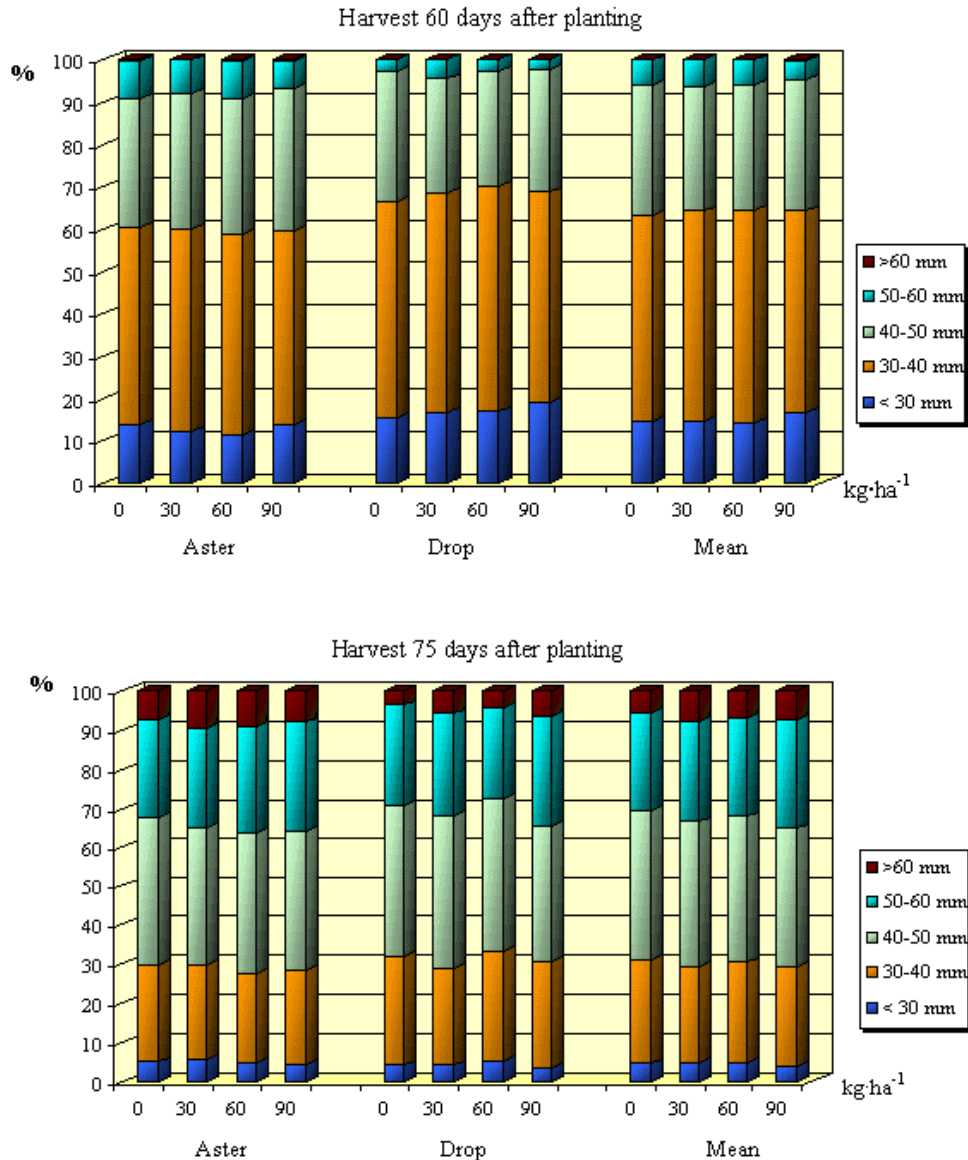
On average, the tubers which were 30-40 mm in diameter constituted the main portion of the yield harvested after 60 days from planting – 49.18%, and the tubers 40-50 mm in diameter, harvested after 75 days from planting – 36.99%. The use of agrotextile cover reduced the portion of the small tubers (below 30 mm in diameter), especially at the very early date of harvest (fig. 1). The portion in the yield of small tubers, below 30 mm in diameter, obtained by means of the discussed method and harvested after 60 days from planting, was smaller on average by 7.2%, than in the cultivation without plants covering. Simultaneously, the yield proportion including tubers which were 40-50 mm in diameter was higher on average by 8.46%, and tubers above 50 mm in diameter – by 2.91%. The effect of the potato cultivation method on the yield structure was smaller in the case of the harvest after 75 days from planting. At that harvest date, the portion of the yield of small tubers on the plots under agrotextile covering was smaller on average only by 1.76%, in comparison with the cultivation without cover. Simultaneously, the portion in the yield of large tubers, above 50 mm in diameter, was higher on average only by 2.19%, in the cultivation with agrotextile covering.

Fig. 1. The effect of potato cultivation method on the tubers yield structure, % weight



The level of nitrogen fertilization had an insignificant effect on the structure of the tuber yield at both dates of harvest (fig. 2). The differences between proportions in the yield of particular tuber fractions ranged from 0.17% to 2.65% at the first date, and from 0.98% to 3.41% at the second date of potato harvest.

Fig. 2. The effect of nitrogen fertilization on the tubers yield structure, % weight



The yield structure of the ‘Aster’ cultivar was more profitable and remained independent on the method of cultivation and nitrogen fertilization level. The weight of the tubers below 30 mm in diameter, harvested after 60 days from planting averaged 12.73% of the yield of this cultivar. The portion of small tubers in the ‘Drop’ cultivar yield was higher on average by 4.23%. On average, the large tubers amounted to 8.27% of the ‘Aster’ cultivar yield. The portion of large tubers in the yield of the ‘Drop’ cultivar was two and a half times as small. After a two-week delay of potato harvest, the portion of small tubers in the yield of both cultivars was similar. The weight of large tubers on average amounted to 35.21% of the ‘Aster’ cultivar yield. The portion of large tubers in the ‘Drop’ cultivar yield was smaller by 4.32%, on average (fig. 1).

DISCUSSION

The use of agrotexile covering in potato cultivation for early harvest advancing the growth and development of plants, which enables obtaining earlier tuber yield, in comparison with the cultivation without plant covering. In addition, it has a positive effect on the tuber yield structure [6, 10, 15, 17, 18, 20, 22], which was confirmed by the discussed studies. More favourable effects of the use of covers are observed at very early dates of potato

harvest. The later the harvest date, the smaller the effect. In the presented studies, covering the plants with agrotexile increased the marketable tuber yield harvested after 60 days from planting on average by 30.11%, and after 75 days from planting by 12.74%, compared to the traditional method. Using the agrotexile covers increased the marketable tubers yield by over 70% after 60 days from planting, in the Poznań and Wrocław region, whereas after about two-week delay of potato harvest, the increase in the marketable tubers yield resulting from the use of agrotexile amounted to 16-17% in the Poznań region and 30% in the Wrocław region [7, 15].

The effect of cover use, reflected in the form of an increased yield, depends on weather conditions in the initial period of potato vegetation. A greater increase in the tuber yield is obtained in the years with cool spring [10, 16], which was confirmed by the discussed studies. In the year 2001, with the lowest average temperature in April and May, the total and marketable tuber yields after 60 days from planting were respectively two and a half times and three times as high as on the control plot.

The use of agrotexile covering results in a greater proportion of marketable tubers in the total tuber yield and a greater proportion in the yield of large tubers, which are over 50 mm in diameter [15, 16, 17, 22], which was confirmed by the presented studies.

In order to obtain high potato tuber yield, proper nitrogen fertilization should be applied. Nitrogen fertilization insufficiency limits plant yielding, while excessive fertilization results in leaching this component to groundwater [2]. Too high nitrogen doses delay tuber growth, do not increase tuber yield and often worsen tuber quality. Thus, in the potato cultivation of early harvest, too high doses of nitrogen should not be applied. The level of nitrogen fertilization should be adjusted to cultivar requirements and the harvest date. The earlier the potato harvest, the smaller the dose of nitrogen should be [4, 11, 13, 19, 23, 24, 25].

Jastrzębska and Jabłoński [5] showed that, in the Pomerania conditions, the highest yielding of the 'Aster' cultivar followed the dose of 40 kg N·ha⁻¹, with no respect to the date of harvesting. The highest tuber yield of the 'Drop' cultivar was obtained after 60 days of vegetation and the dose of 80 kg N·ha⁻¹, and after 75 days of vegetation and at the dose of 120 kg N·ha⁻¹. The study carried out in the Wrocław region by Prośba-Białczyk and Mydlarski [15] showed that, after 56-58 days from planting, the dose of 80 kg N·ha⁻¹ did not significantly increase the tuber yield of the 'Aster' and 'Drop' cultivars, in comparison with the dose of 40 kg N·ha⁻¹. However, the dose of 80 kg N·ha⁻¹ positively influenced the tuber yield harvested after 70-72 days from planting. In the presented studies, the level of nitrogen fertilization did not influence significantly the tuber yield of the 'Aster' and 'Drop' cultivars. It may have resulted from precipitation shortages in the period of plant vegetation, especially in the years 2000 and 2001. Both water shortage and surplus in the vegetation period considerably limit the nitrogen utilization by potato plants [9].

The proper choice of the cultivar in the potato cultivation for early harvest is very important. The 'Aster' cultivar was more fertile and the portion in its yield of large tubers was greater than for the 'Drop' cultivar, which was confirmed by the studies by Prośba-Białczyk and Mydlarski [15] as well as Pszczołkowski and Sawicka [16]. In the presented studies, the marketable tuber yield of the 'Aster' cultivar was higher on average by 2.43 t·ha⁻¹ (30.57%) after 60 days from planting. At the later date of potato harvest the differences in the yields of both cultivars were smaller. The 'Aster' cultivar responded to the application of the agrotexile covers by increasing its yield more than the 'Drop' cultivar, which was confirmed by the studies of Prośba-Białczyk and Mydlarski [15].

CONCLUSIONS

1. The use of the agrotexile cover increased the marketable tuber yield after 60 days from planting on average by 30.11%, and after 75 days from planting by 12.74%, during the three-year period of the research. In the year with cool spring, the tuber yield in the cultivation under agrotexile was twice as high as in the traditional cultivation, in respect to a very early harvest date.
2. The use of agrotexile in the potato cultivation for early harvest, favourably influences the yield structure, first and foremost, the fraction of large tubers which are 50 mm in diameter.
3. Higher tuber yield increase, resulting from the use of the cover, was obtained in the cultivation of the 'Aster' rather than 'Drop' cultivar.
4. Nitrogen fertilization, within the range of the investigated doses, significantly influenced neither the tuber yield nor its structure.
5. The higher yield, with the higher portion of the weight of large tubers, was characteristic of the Aster and not Drop cultivar.

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