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A POSSIBILITY OF INCREASING THE YIELD OF YOUNG POTATO TUBERS BY USING A POLYPROPYLENE FIBRE COVER

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ABSTRACT

The studies examined the effect of polypropylene fibre Pegas Agro 17 covering (from planting till full emergence and up to the height of about 15 cm) on the yielding of very early cultivars of potato. Covering with the fibre till full emergence caused an increase of commercial tubers yield 60 days after planting by 20-30% on average during the years with warm spring, and by 240% during a year with cold winter. 75 days after planting the increase was 8% and 37%, respectively. The proportion of big tubers was greater. A longer period of covering did not cause any significant increase of the tuber yield. The use of covers contributed to a greater yield of 'Koral' and 'Malwa' cultivars as compared to 'Aster' and 'Orlik'.

Key words: arly potato, cultivation under cover, polypropylene fibre, yield

INTRODUCTION

Potato cultivation for early harvest requires good weather conditions, especially in April and May, when there is a big danger of ground frosts. The use of covers right on the field with planted potatoes ensured favourable conditions for the growth of plants.

Potato cultivation for early harvest under covers has been applied for many years in Germany, France, Belgium, Holland and England [1, 2, 3, 6, 7, 13, 15]. In Poland, studies on the use of covers in field cultivation of potato started at the beginning of 1990's [4, 8, 14, 16]

The use of covers changes the conditions of early growth and development of potatoes, as a result accelerating the collection of the yield. The results of studies showed that the use of covers in potato cultivation for early harvest makes it possible to achieve a higher yield of tubers even by 70-200%, as compared to the cultivation with no covers [2, 4, 5, 11, 13, 14]. It also has a positive influence on the structure of the tubers yield [10, 11, 12]. The effect of using covers was significantly related to the weather conditions and the date of collecting potatoes.

The purpose of the studies was to determine the effect of using covers of polypropylene fibre on the yield of young potato tubers in the area of south-eastern Poland.

MATERIAL AND METHODS

The studies were carried out in south-eastern Poland in the years 1997-1999, on brown soil, class IVa, with pH = 5.5-5.9, with mean content of available phosphorus and potassium and with the content of magnesium ranging from low to medium.

The field experiment was conducted in a split-block scheme in three replications. It examined the effect of the manner of cultivation – without covers, polypropylene fibre Pegas Agro 17 from the planting till full emergence, polypropylene fibre Pegas Agro 17 from the planting till plants achieved the height of around 15 cm – on the size and structure of the yield of very early potato cultivars 'Koral', 'Aster', 'Malwa' and 'Orlik'.

Potatoes grew on the sites after cereals. Manure in the dose of 30 t·ha⁻¹ was applied in autumn. Mineral fertilizers were used during the spring cultivation of the field. The quantities were 60 kg N, 60 kg P₂O₂ and 90 kg K₂O for potatoes meant for gathering 60 days after planting, and 90 kg N, 90 kg P₂O₅ and 120 kg K₂O per 1 ha of potatoes meant for collection 75 days after planting. In successive years of studies seed-potatoes germinating for the period of 6 weeks were planted on 26, 15 and 9 April, at the spacing of 62.5×30 cm. The area of one plot was 15 m². Potatoes were collected at two dates – 60 and 75 days after planting. At each date, the total tubers yield and the commercial tubers yield were determined. The commercial yield consisted of tubers with the diameter of over 30 mm (PN-75/R-74453). During the harvest, about 5 kg of sample tubers were taken from each object in order to establish the yield structure and the average weight of one tuber. Tuber fractions were distinguished with the diameter of less than 30 mm, 30-40 mm, 40-50 mm, 50-60 mm and more than 60 mm.

The results were statistically analysed. The significance of differences was determined by means of Tukey's test with the level of significance $\alpha = 0.05$.

Table 1. Mean air temperatures (°C) and sums of rainfalls (mm) during potato vegetation

Years	Air temperature				Rainfalls			
	Months							
	April	May	June	July	April	May	June	July
1997	5.1	14.9	17.7	19.9	21.5	24.5	51.5	191.3
1998	9.9	14.0	17.3	17.4	41.0	63.0	109.0	40.5
1999	9.9	12.9	20.5	21.8	87.3	26.4	121.7	21.9
Mean figure of many years, 1951-1990	9.2	13.2	16.2	17.6	29.4	54.3	69.3	70.6

Weather conditions during the studies were differentiated ([table 1](#)). They were favourable for potato cultivation for early harvest only in 1998. In 1997, very cold April and long-lasting snow cover did not allow for early planting of potatoes. However, May and June, which were warmer in comparison to the mean value of many years in that region, created positive conditions for fast growth and development of plants. In 1999, after very warm first ten days of April, a significant drop of temperature until the third ten days' period was observed. The amount of rainfalls during potato vegetation was sufficient for the proper growth and development of plants, but their distribution in particular months was not too favourable, especially in 1997 and 1999.

RESULTS

Differentiated weather conditions during the vegetation of potatoes had a significant effect on the yield of tubers and the weight of one tuber. Higher yields were achieved in moderately warm and humid years of 1997 and 1998 than in 1999. In 1999, the development of plants and the growth of tubers were limited by cool May and excessive rainfalls in June, with fairly high air temperature ([tables 2, 3, 4](#)). In 1997, which had the lowest air temperatures in May and June, the average weight of one tuber 60 days after planting was twice as big, and 75 days after planting one and a half times as big as in 1999, which was the least favourable for potato cultivation for early collection.

Table 2. The yield of potato tubers 60 days after planting (t·ha⁻¹)

Manner of cultivation	Cultivar	Total yield of tubers				Commercial yield of tubers			
		1997	1998	1999	mean	1997	1998	1999	mean
1	Aster	27.16	21.00	4.89	17.68	26.01	18.20	1.81	15.34
	Koral	24.05	15.33	1.91	13.76	23.31	11.59	0.28	11.73
	Malwa	23.91	14.67	4.13	14.24	23.40	13.05	0.90	12.45
	Orlik	25.82	21.33	7.33	18.16	25.42	20.39	3.93	16.58
	mean	25.24	18.08	4.56	15.96	24.54	15.81	1.73	14.02
2	Aster	32.89	24.22	8.67	21.93	31.49	21.08	4.96	19.18
	Koral	26.22	19.33	7.20	17.58	25.28	15.47	4.33	15.03
	Malwa	27.67	22.22	8.89	19.59	27.44	19.95	5.10	17.49
	Orlik	33.82	28.00	11.64	24.49	33.09	26.43	9.22	22.91
	mean	30.15	23.44	9.10	20.90	29.32	20.73	5.90	18.65

3	Aster	29.78	23.33	11.10	21.40	28.68	20.83	8.17	19.22
	Koral	25.60	19.11	7.82	17.51	25.06	16.62	4.61	15.43
	Malwa	24.85	18.22	9.72	17.60	24.59	16.21	6.15	15.65
	Orlik	30.40	27.33	12.75	23.50	30.08	26.25	10.62	22.32
	mean	27.66	22.00	10.35	20.00	27.10	19.98	7.39	18.15
mean for cultivars	Aster	29.94	22.85	8.22	20.34	28.72	20.04	4.98	17.91
	Koral	25.29	17.92	5.64	16.28	24.55	14.56	3.07	14.06
	Malwa	25.48	18.37	7.58	17.14	25.14	16.40	4.05	15.20
	Orlik	30.01	25.56	10.58	22.05	29.53	24.36	7.92	20.60
mean for years		27.68	21.18	8.00	18.95	26.98	18.84	5.01	16.94
NIR _{0.05} :									
years		1.33				1.15			
manner of cultivation		1.33				1.15			
years × manner of cultivation		n.i. **				1.99			
cultivar		1.55				1.71			
years x cultivar		2.42				2.67			

*Manner of cultivation: 1 – without covering, 2 – polypropylene fibre till full emergence, 3 – polypropylene fibre till the height of about 15 cm

**n.i. – not significant differences

The use of polypropylene fibre covers contributed to a significant increase of the yield of young potato tubers and the average weight of one tuber as compared to the cultivation without covering the plants. Fibre covers in the period from planting till full emergence caused an increase of the total yield of tubers 60 days after planting by 4.94 t·ha⁻¹ (31%) on average, and an increase of the commercial yield of tubers by 4.63 t·ha⁻¹ (33%) as compared to the control object without covering. Using the same manner but 75 days after planting, the total yield of tubers was higher by 3.51% t·ha⁻¹ (12%) on average and the commercial yield of tubers was higher by 3.72% t·ha⁻¹ (13%). At both dates of potato collection, the yields of tubers from the objects covered with fibre in the period from planting to the height of about 15 cm did not differ significantly from the yields achieved with the use of covers till full emergence of potatoes ([tables 2, 3](#)).

The average weight of one tuber from the objects covered with fibre in the period from planting till full emergence was higher by 5.47 g (18%) 60 days after planting, and by 7.98 g (16%) 75 days after planting in comparison with the control without covers ([tab. 4](#)). The average weight of one tuber from the objects covered with fibre in the period from planting to the height of about 15 cm was slightly smaller than from the objects where a cover was used till full emergence, however, the difference was not statistically confirmed.

The effect of the use of covers, reflected in an increase of the tuber yield in comparison to the cultivation without covers, was differentiated in particular years of studies ([tables 2, 3](#)). The greatest increase of the tuber yield as a result of the use of covers was achieved in 1999, when the lowest mean air temperature was observed in May. Fibre covers in the period from planting till full emergence caused an increase of the total tuber yield 60 days after planting by 100% on average, and an increase of the commercial tuber yield by 240%. In 1997 and 1998, with warmer spring, the effect of covers was smaller. In the cultivation with covers the commercial tuber yield was higher by 20% in 1997 and by 30% in 1998. Similar differences

were found out in the total tuber yield. The effect of the use of covers was smaller at a later date of potato picking. Fibre covers used in the period from planting to full emergence caused an increase of the commercial tuber yield 75 days after planting by 37% on average in the year with cool spring, and by about 8% in the years with warm spring. The use of covers in the period from planting till potatoes reached the height of about 15 cm gave slightly better effects than covering till full emergence only in the year with cool spring. However, differences in the yields were small and they were not statistically proved.

Table 3. The yield of potato tubers 75 days after planting (t·ha⁻¹)

Manner of cultivation*	Cultivar	Total yield of tubers				Commercial yield of tubers			
		1997	1998	1999	mean	1997	1998	1999	mean
1	Aster	45.11	38.44	10.27	31.27	43.49	36.77	9.06	29.27
	Koral	38.13	28.11	14.67	26.97	37.93	27.43	13.65	26.33
	Malwa	33.24	30.11	13.82	25.73	33.15	29.67	13.03	25.28
	Orlik	35.91	33.78	26.71	32.13	35.37	33.22	26.31	31.63
	mean	38.10	32.61	16.36	29.02	37.48	31.77	15.51	28.26
2	Aster	47.29	40.22	16.22	34.58	46.62	38.86	15.20	33.59
	Koral	42.71	32.11	20.54	31.79	42.71	30.67	20.23	31.20
	Malwa	38.84	34.44	19.87	31.05	38.72	33.83	19.40	30.65
	Orlik	33.51	34.22	30.40	32.71	33.23	34.11	30.09	32.48
	mean	40.59	35.25	21.76	32.53	40.32	34.36	21.26	31.98
3	Aster	47.16	35.56	19.42	34.04	46.61	32.63	18.59	32.61
	Koral	44.11	31.33	21.47	32.30	43.58	29.15	20.95	31.23
	Malwa	36.38	34.45	22.53	31.12	36.03	33.19	22.40	30.54
	Orlik	39.09	31.11	32.93	34.38	38.78	30.46	32.40	33.88
	mean	41.68	33.11	24.09	32.96	41.25	31.36	23.58	32.06
mean for cultivars	Aster	46.52	38.07	15.30	33.30	45.57	36.09	14.32	31.99
	Koral	41.65	30.52	18.89	30.35	41.41	29.08	18.28	29.59
	Malwa	36.15	33.00	18.74	29.30	35.97	32.23	18.27	28.82
	Orlik	36.17	33.04	30.01	33.07	35.79	32.60	29.60	32.66
mean for years		40.12	33.66	20.74	31.51	39.68	32.50	20.12	30.77
NIR _{0.05} :									
years		1.63				1.70			
manner of cultivation		1.63				1.70			
years x manner of cultivation		2.83				2.95			
cultivar		2.69				2.65			
years x cultivar		4.20				4.14			
manner of cultivation x cultivar		2.03				2.13			
years x manner of cultivation x cultivar		3.52				3.68			

*Manner of cultivation: 1 – without covering, 2 – polypropylene fibre till full emergence, 3 – polypropylene fibre till the height of about 15 cm

*n.i. – not significant differences

Independently of the manner of potato cultivation, the tuber yields of ‘Aster’ and ‘Orlik’ cultivars were higher by 3-6 t·ha⁻¹ on average 60 days after planting, and by 3-4 t·ha⁻¹ 75 days after planting as compared to the yields of ‘Koral’ and ‘Malwa’ cultivars (tables 2, 3). Covering the plants with fibre caused a greater increase of the tubers yield for ‘Koral’ and ‘Malwa’ cultivars than for ‘Aster’ and ‘Orlik’ cultivars, especially when they were picked 75 days after planting.

Independently of the manner of potato cultivation, the greatest weight was observed for the tubers of ‘Orlik’ cultivar: 40.57 g on average 60 days after planting, and 65,24 g 75 days after planting, while the smallest weight was found for the tubers of ‘Aster’ cultivar: 30.96 g and 44.76 g, respectively (table 4).

Table 4. Average weight of one potato tuber (g)

Manner of cultivation	Cultivar	Date of harvest							
		60 days after planting				75 days after planting			
		1997	1998	1999	mean	1997	1998	1999	mean
1	Aster	36.34	30.30	16.62	27.75	42.31	44.27	31.96	39.52
	Koral	45.80	26.64	15.43	29.29	67.15	53.37	37.31	52.61
	Malwa	43.47	25.91	16.12	28.50	69.25	56.06	34.10	53.14
	Orlik	49.11	38.80	18.76	35.56	60.96	70.26	46.56	59.26
	mean	43.68	30.41	16.73	30.27	59.92	55.99	37.48	51.13
2	Aster	39.73	38.31	19.90	32.64	56.77	52.68	34.96	48.14
	Koral	48.34	31.89	18.26	32.83	78.51	52.71	50.70	60.64
	Malwa	50.21	35.08	18.69	34.66	71.20	59.01	41.99	57.40
	Orlik	53.87	48.54	26.10	42.83	67.78	86.93	56.13	70.28
	mean	48.04	38.46	20.74	35.74	68.56	62.83	45.94	59.11
3	Aster	41.10	34.00	22.31	32.47	59.27	39.78	40.84	46.43
	Koral	43.18	31.02	19.28	31.16	73.80	54.48	45.74	58.01
	Malwa	49.05	28.32	20.33	32.57	58.59	57.56	48.82	54.99
	Orlik	55.97	46.01	27.99	43.32	77.53	65.97	55.03	66.18
	mean	47.32	34.84	22.48	34.88	67.30	54.45	47.61	56.45
mean for cultivars	Aster	39.06	34.20	19.61	30.96	52.79	45.58	35.92	44.76
	Koral	45.77	29.85	17.65	31.09	73.15	53.52	44.58	57.08
	Malwa	47.57	29.77	18.38	31.91	66.35	57.54	41.64	55.17
	Orlik	52.98	44.45	24.28	40.57	68.76	74.39	52.57	65.24
mean for years		46.34	34.57	19.98	33.63	65.26	57.76	43.68	55.56
NIR _{0.05} :									
years		2.87				6.41			
manner of cultivation		2.87				6.41			
years x manner of cultivation		n.i.				n.i.			
cultivar		4.34				5.84			
years x cultivar		6.77				9.11			
years x manner of cultivation x cultivar		n.i.				10.62			

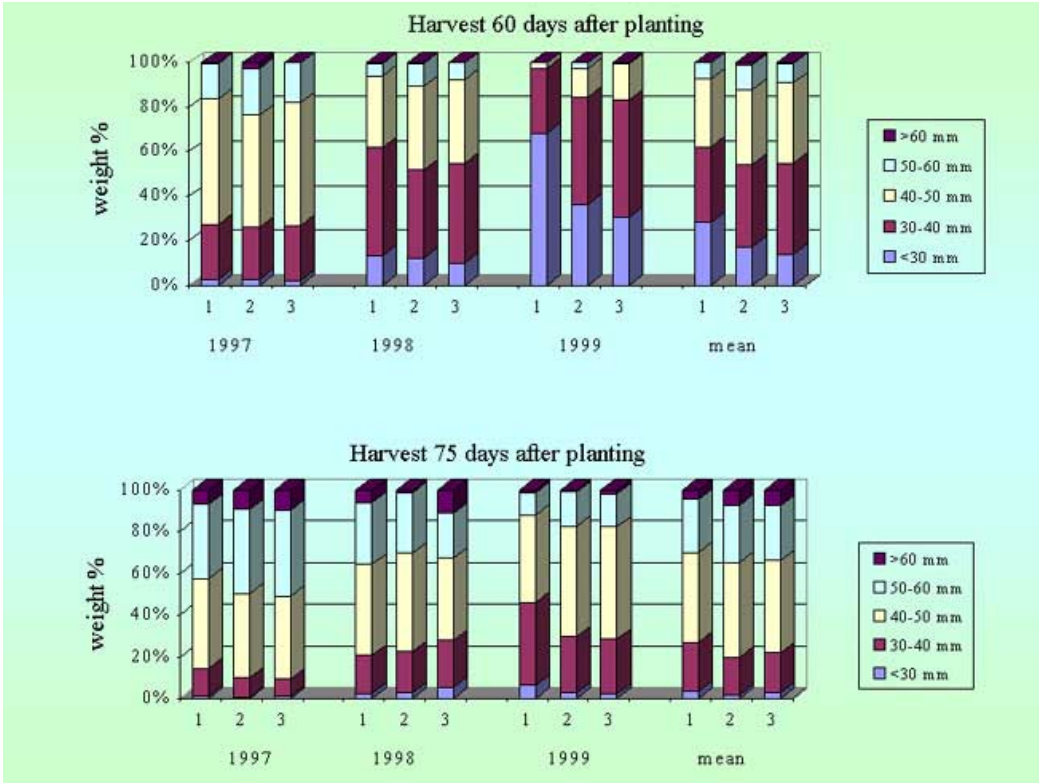
*Manner of cultivation: 1 – without covering, 2 – polypropylene fibre till full emergence, 3 – polypropylene fibre till the height of about 15 cm

**n.i. – not significant differences

Differentiated weather conditions in the period of potato vegetation had an effect both on the size of the yield and its structure (figure 1). The best conditions for the growth of tubers were in 1997, with the highest air temperature in May and June. 60 days after planting nearly 50% of the yield was made of the mass of tubers with the diameter of 40-50 mm. There were very few small tubers, with the diameter lower than 30 mm. In the remaining years of studies the tubers were smaller, and the main mass of the yield was composed of tubers with the diameter of 30-40 mm. In 1999, which had the lowest air temperature in May, almost 45% of the yield was made up of the mass of tubers with the diameter of less than 30 mm. 75 days after planting, the proportion of small tubers in the yield of 1997 was more than three times as small as in 1998 and 1999. Almost 50% of the yield was composed of the mass of big tubers with the diameter of over 50 mm. In the other years of studies, the main mass of the yield was made up of tubers with the diameter of 40-50 mm.

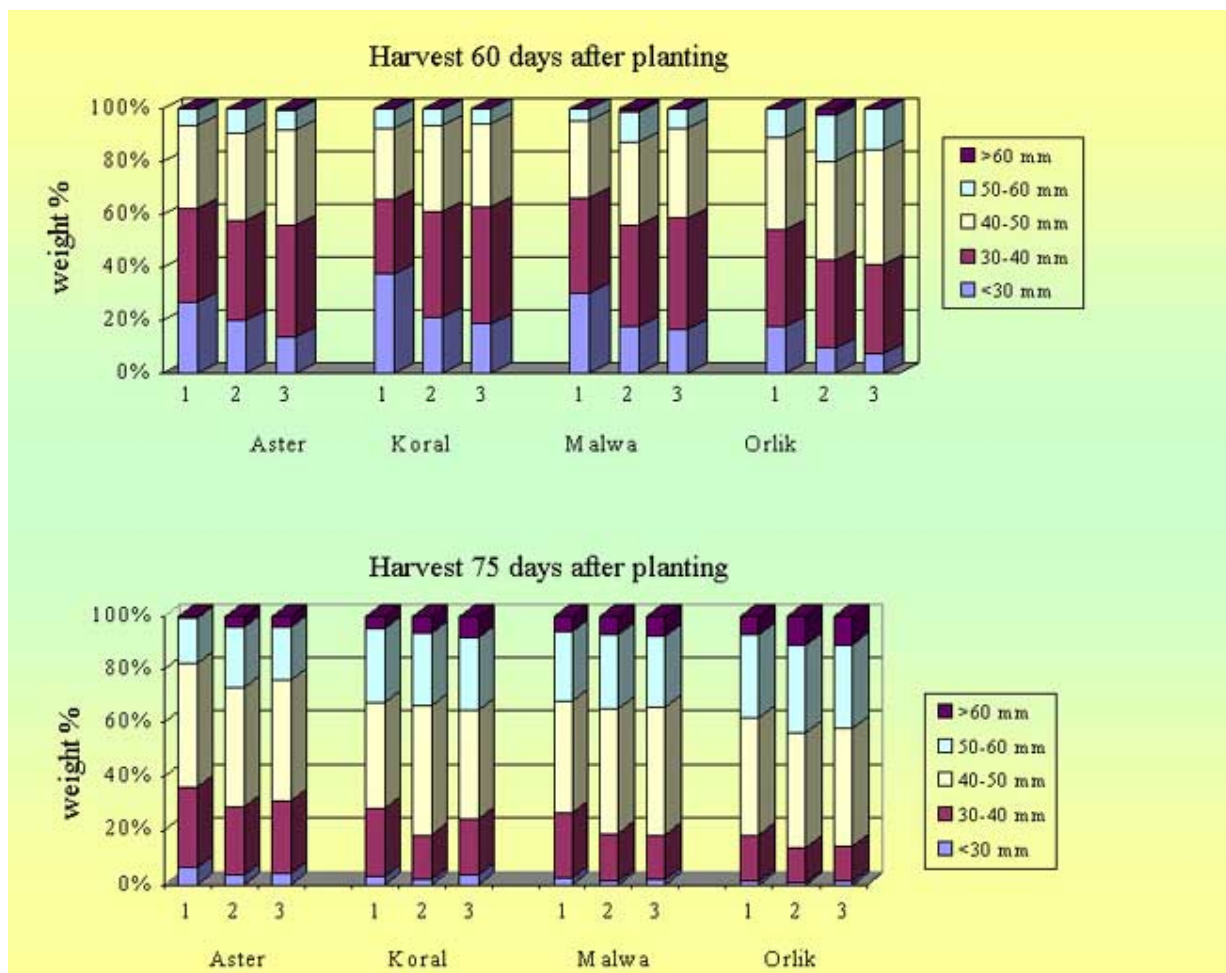
The size of tubers in the yield was related to the manner of potato cultivation (figure 1). Greater differences were found in the mass of small and big tubers, while the weight of medium-sized tubers changed in a lesser degree. Fibre covering in the period from planting till full emergence caused a decreased proportion of non-commercial tuber in the yield by 11% on average 60 days after planting, and by 1.5% 75 days after planting in comparison with the cultivation without covers. With this manner of cultivation, the proportion of big tubers with the diameter of over 50 mm in the yield was higher by about 5% at both dates of the harvest. A longer period of keeping the cover over the plants had a slight influence on the structure of the tuber yield.

Figure 1. Percentage share of (the mass of) tubers fractions in the yield in 1997-1999 (% weight); manner of cultivation: 1 – without covering, 2 – polypropylene fibre till full emergence, 3 – polypropylene fibre till the height of about 15 cm



Independently of the manner of potato cultivation, the lowest proportion of small tubers was found in the yield of 'Orlik' cultivar (figure 2). The weight of tubers with the diameter of less than 30 mm constituted 11.5% of the yield of this cultivar 60 days after planting, and 1.3% of the yield 75 days after planting. At the first date of harvest the proportion of small tubers of 'Aster', 'Koral' and 'Malwa' cvs. was twice as big, while at a later date the proportion of small tubers in the yield of 'Koral' cv. was 2.5 times as big as the proportion of 'Orlik' cv. The proportion of such tubers in 'Aster' cv. was nearly 4 times as big. The weight of big tubers with the diameter of over 50 mm constitutes 15.5% on average of the yield of 'Orlik' cv. gathered 60 days after planting, and 41% of the yield gathered 75 days after planting. At the first date, the proportion of big tubers in the yields of the other cultivars was smaller by 7.5-9.0% on average, and at the second the proportion of big tubers in the yields of 'Koral' and 'Malwa' cvs. was by 7% smaller, and in the yield of 'Aster' cv. by 18%.

Figure 2. The structure of tubers yield relative to the method of cultivation and potato cultivar (% weight)
 – means of 1977-1999; manner of cultivation: 1 – without covering, 2 – polypropylene fibre till full emergence, 3 – polypropylene fibre till the height of about 15 cm



DISCUSSION

The use of covers in potato cultivation for early harvest accelerates the emergence and growth of plants as well as the development of assimilation area. It has a positive effect on the size and structure of the yield and above all on the efficiency in the yield of commercial tubers

[2, 10, 12, 13, 14]. Better effects of the use of covers are observed at very early dates of potato collection. The later the date of harvest is, the smaller the effect of the covers reflected in the increase of the tuber yield as compared to the cultivation in an open field [8, 12, 14], which was confirmed by the present studies. Covering with fibre in the period between planting and full emergence brought about an increased yield of commercial tubers 60 days after planting by about 31%, and a greater average weight by 18% in comparison with the cultivation without covering. Using this method of potato cultivation but picking the plants two weeks later, the yield of commercial tubers was increased by 13% on average and the mean weight of one tuber by 16%. The use of covers till the time when plants reached the height of about 15 cm did not cause any significant changes in the size of the tuber yield. During the years with warmer spring leaving a cover over the plants after emergence can limit the development of assimilation area, while during the years with lower temperatures it gives a positive result [9].

The effect of covering potato with fibre in the form of an increased yield is related to weather conditions during vegetation. A greater increase of the tuber yield as a result of using covers is achieved in the years with cool spring [8, 11]. In the conditions of central Poland, covering with fibre in the period between planting and the time when plants reach the height of about 12-15 cm caused an increased yield of tubers 60 days after planting by about 20% during the year with warm spring and by 30% during the year with cool spring [8]. The present studies conducted in central-eastern Poland showed that covering the plants with fibre caused an increase of the commercial tubers yield 60 days after planting by about 240% in the year that was least favourable for the growth and development of potatoes in respect of weather conditions, and by 20% in the year favourable for the vegetation of early potato cultivars.

The effect of using polypropylene fibre covers in potato cultivation on the early harvest is related to the cultivar. Therefore, the proper choice of the cultivar is very important. The use of covers gave better results in the case of 'Aster' cultivar than 'Drop' cultivar [11]. The studies also showed greater usability of 'Malwa' cv. for the cultivation under covers than 'Drop' [4]. In the conditions of the studies, covering with fibre caused a greater increase of the tuber yield for 'Koral' and 'Malwa' than 'Aster' and 'Orlik'.

Besides the size of the yield, the size of the tubers in it is very important in potato cultivation for early collection. A smaller yield of bigger tubers has greater value than a high yield consisting mostly of small tubers. The use of fibre covering results in a greater proportion of commercial tubers in the yield and at the same time a greater proportion of big tubers, with the diameter over 50 mm [10, 11, 12], in the yield, which was confirmed by the present studies. The size of tubers in the yield depends on the cultivar properties. Independently of the manner of potato cultivation, 'Orlik' was the cultivar with the best yield structure, i.e. with the greatest proportion of big tubers in the yield.

CONCLUSIONS

1. As compared to the cultivation without covers, the use of polypropylene fibre covering in the period between planting and full emergence of potatoes made it possible to achieve a higher yield of commercial tubers by 20-30% on average 60 days after planting in the years with warmer spring, and as much as by 240% in the year with cold winter.
2. With this method of potato cultivation but at the date of harvest 2 weeks later, the effect of covering reflected in an increase of commercial tubers yield was smaller and

it was 37% on average in the year with cold winter, and about 8% in the years with warm spring.

3. The period of keeping covers over the plants had no significant effect on the tubers yield. It was only in the year with the lowest air temperature after potato emergence that the use of covering in the period between planting and the time when plants reached the height of about 15 cm gave slightly better results than covering till full emergence.
4. A greater increase of the tubers yield as a result of using covers was achieved in the cultivation of 'Koral' and 'Malwa' cultivars than for 'Aster' and 'Orlik'.
5. Independently of the method of potato cultivation, 'Orlik' cv. was the most productive cultivar, with the highest proportion of big tubers.
6. The use of polypropylene fibre covering in the cultivation of early potato cultivars contributed to a better yield structure through an increased proportion of big tubers, with the diameter of over 50 mm, in the yield. With this method of cultivation, the average weight of one tuber 60 days after planting was greater by 18% on average, and 75 days after planting it was greater by 16% in comparison with the cultivation without covering.

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