Effect of perforated foil and polypropylene fibre covers on development of early potato cultivars

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ABSTRACT

The effect of perforated polyethylene foil and polypropylene fibre cover on the development of the early potato cultivars Aksamitka and Cykada was investigated. The use of the covers resulted in an increase in the soil temperature at the depth of 100 mm on average by 2.2°C at 8 a.m. and by 4.0°C at 2 p.m. in the year with warm spring and by 1.5°C and 3.2°C in the year with cold spring, respectively. A higher increase in the soil temperature, on average by 1–2°C, was caused by the use of the perforated foil than by the use of the polypropylene fibre. The increase in the soil temperature as a result of covering forced the plant emergence on average by 5 days and shortened the period from planting to tuber setting by 5 days in comparison with the cultivation with no plant covering. The higher favourable effect of covering was obtained in the year with the lowest air and soil temperatures in May. The use of the covers at that time forced the plant emergence and shortened the period from planting to tuber setting on average by 6 days. A higher soil temperature increase was observed under the perforated foil than under the polypropylene fibre, which resulted in an earlier occurrence of the successive plant development phases, on average by 1–2 days.

Keywords: early potato; perforated polyethylene foil; polypropylene fibre; soil temperature; plant development

The success of potato cultivation for an early crop depends to a higher degree on the weather conditions in the initial period of plants vegetation (Chotkowski et al. 1995). In Poland climatic conditions early potatoes from field production are harvested in mid-June, and in the regions characterized by less favourable thermal conditions not until the beginning of July. Soil temperature is the most limiting environmental factor for the early planting of the potato (Nishibe at al. 1989). Too low soil temperature retards the plant emergence. For the potato development and yield accumulation a proper temperature distribution in the successive plant development phases is very important. For the production of early potatoes higher temperatures in April and May are essential, as they enable an early planting and a quick plant development. Good conditions for the growth and development of plants occur when the soil is heated up to 5–6°C at the beginning of April, and when the average air temperature in May amounts to approximately 14°C and to 17°C in June (Chotkowski at al. 1995). In Poland a very early potato production is risky because of the occurrence of spring ground frost in some regions of the country, which not only retards the date of planting, but also slows down the emergence and inhibits the initial plant growth. This results in the lengthening of the growth of the above-ground plant parts and in a delay in the tuber setting as well as in a slower increase in tuber yield. Hence, it is necessary to investigate ways allowing an earlier planting in less warm soils and forcing of plant vegetation. The favourable microclimatic conditions at the beginning of plant vegetation may be provided by the use of covers directly on the planted field. In Europe the covers that are most frequently used in the potato cultivation for early crop are those of perforated polyethylene foil (Friessleben 1984, Hamouz and Rybáček 1988, Nelson and Jenkins 1990, Jenkins and Gillison 1995). A white polypropylene fibre is also a good protective material (Prośba-Białczyk and Mydlarski 1998, Dvořák et al. 2004, Hamouz et al. 2006).

This paper presents the results of a three-year research on the effect of perforated polyethylene foil and polypropylene fibre covering on the development phases of plants in potato cultivation for an early crop in the middle-eastern part of Poland.

MATERIAL AND METHODS

The effect of perforated polyethylene foil and polypropylene fibre covering on the development of early potato cultivars Aksamitka and Cykada was investigated in this experiment; it was carried out in the years 2002–2004 in the middle-eastern part of Poland on a light soil, characterized by mean to very high content of available phosphorus, low to mean content of potassium, mean to high content of magnesium, and pH 6.1–6.7. The field experiment was established in the split-block method with a control object without covering in three replications. In the successive years the 8-week seed potatoes pre-sprouted in the temperature 12–15°C were planted on 9, 16, and 13 April, with a row spacing of 300 mm and 625 mm between rows. The average length of sprouts at the time of planting amounted to 15–20 mm. The plots were four rows wide and 6 m long. Immediately after planting and before covering the herbicide was applied (linuron – trade name Afalon 450 SC, Linurex 500 SC). The materials used in the experiment were the perforated polyethylene foil with 100 holes per 1 m^2 and the polypropylene fibre Pegas Agro 17. The covers were removed 2 weeks after the plant emergence. In the years 2003 and 2004 the soil temperature was measured with the thermometer at the depth of 100 mm on the control object without covering and under the covers at 8 a.m. and 2 p m. In the vegetation period the observations of some plant development phases were held, namely plant emergence, flower bud formation, and tuber setting. The monitoring was carried out according to the methodics for observation, measurements, and sample take in agricultural experiments with potatoes of Plant Breeding and Acclimatization Institute (Roztropowicz 1999).

The results of the experiment were analysed statistically by means of analysis of variance. The analysis of the results was conducted using the orthogonal contrast to compare the control object without covering with the remaining objects. The significance of differences was verified using the Tukey's test at $P = 0.05$.

In the three-year period of the study, the most favourable climatic conditions for potato cultivation for the early crop were in 2002 (Table 1). In 2003, a very cold first half of April with temporary snow did not allow the early potato planting; however, a considerable warming at the end of the month favoured an early plant emergence. The plant development and tuber growth were inhibited by the drought during the whole period of the potato vegetation. In contrast, the year 2004 was very cold and it had the highest amount of precipitation.

RESULTS AND DISCUSSION

The soil temperature at the depth of 100 mm on the objects with covers was higher than on the control object (Figure 1). Higher temperature differences were noted in 2003 when the mean soil temperature increase as a result of covering was 2.2°C in the morning hours (at 8 a.m.) and 4.0°C at noon (at 2 p.m.); in 2004 these differences amounted to 1.5°C and 3.2°C, respectively. In 2003, in the initial period after potato planting (17–30 April), the mean soil temperature under the perforated foil was higher by 2.0°C at 8 a.m. and by 3.3°C at 2 p.m. compared with the control object with no covering; when the polypropylene fibre was used the differences were smaller and amounted to 1.1°C and 2.3°C, respectively. In the first decade of May, with the use of the perforated foil the soil temperature at 8 a.m. was higher on average by 0.8°C and later (11–27 May) by 0.9°C than in the case of polypropylene fibre covering. At 2 p.m. the differences in temperatures amounted to 1.2°C and 1.6°C, respectively. In 2004, in the initial period after potato planting (13–30 April) the soil temperature under the perforated foil was

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

Years	Soil temperature (°C)		Air temperature (°C)		Precipitation (mm)	
	April	May	April	May	April	May
2002	9.3	17.1	9.0	17.0	12.9	51.3
2003	6.9	15.3	7.1	15.6	13.6	37.2
2004	8.4	13.1	8.0	11.7	35.9	97.0
Mean 1981–2000			8.1	11.2	49.6	48.2

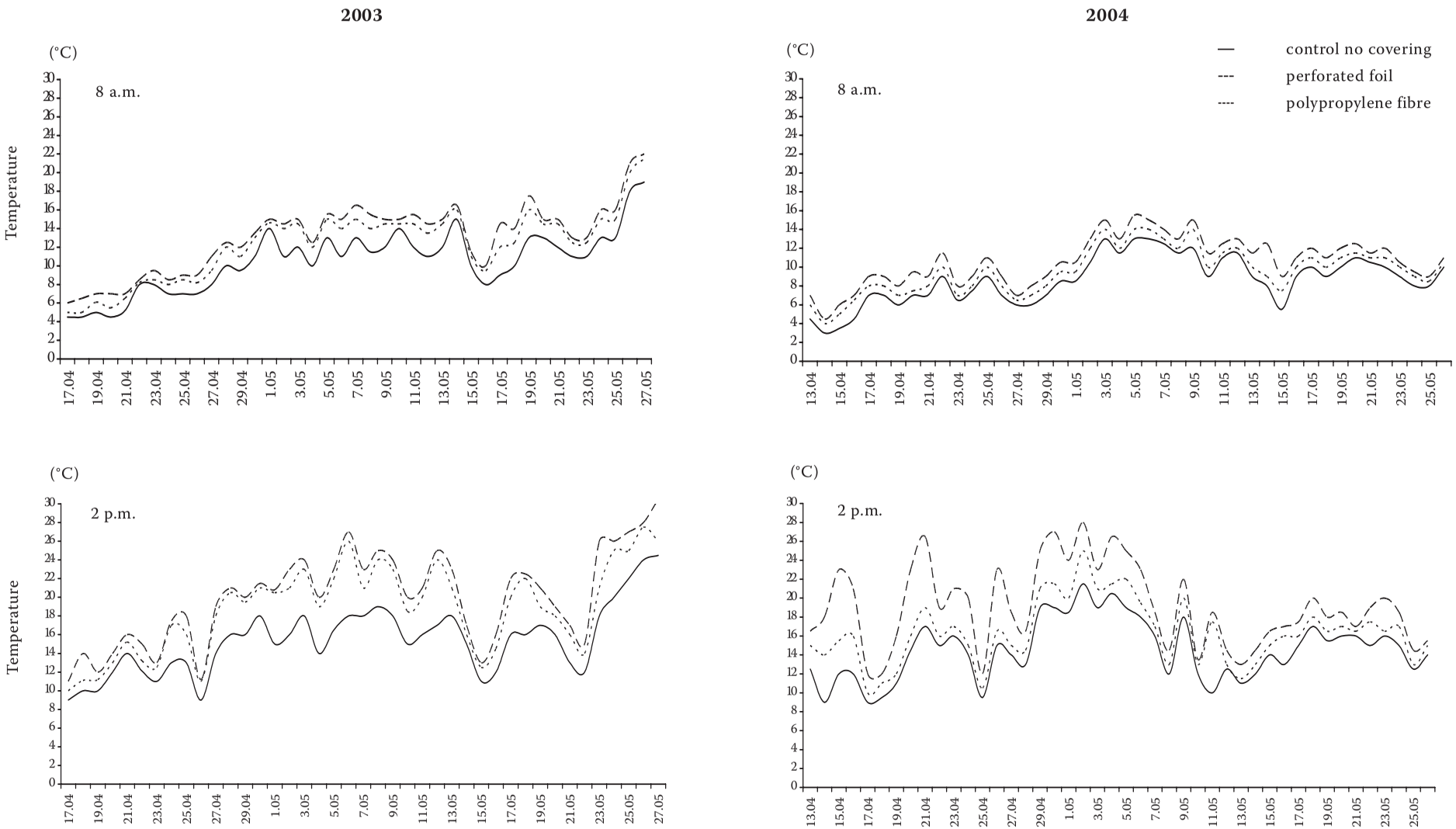

Figure 1. Soil temperature at the depth of 100 mm (°C) depending on the type of cover at 8 a.m. and 2 p.m. in 2003–2004

higher on average by 2.0°C at 8 a.m. and under the polypropylene fibre by 1.0°C compared with the control object; at 2 p.m. the differences in temperature amounted to 6.0°C and 1.9°C. In the first decade of May the soil temperature under the perforated foil was higher on average by 1.2°C at 8 a.m. and by 2.6°C at 2 p.m. than when the polypropylene fibre was used. The temperature differentiation at noon hours reached 5°C. In the later period (11–26 May) the soil temperature difference with the use of the perforated foil and polypropylene fibre was smaller and on average amounted to 1.1°C at 8 a.m. and 1.4°C at 2 p.m. A similar increase in the soil temperature in the initial period after potato planting as a result of the polypropylene fibre use was obtained in the Wrocław region. In the later period (27 April–10 May) the temperature differentiation went up to 5°C (Prośba-Białczyk and Mydlarski 1998). In the Czech Republic the soil temperature during the period with polypropylene fibre covering increased on average by 1.8°C and air temperature by 2.0°C (Hamouz et al. 2006); however, in the study carried out in Wales, a mean daily increase in soil temperature as a result of covering with the perforated foil amounted on average to the values from 2°C to 4°C (Nelson and Jenkins 1990, Jenkins 1993). In the discussed study the soil temperature at the depth of 100 mm with the use of the perforated foil was higher than under the polypropylene fibre on average by 1–2°C; however, in the study carried out by Lutomirska and Szutkowska (1999) in the initial phase of potato growth in the central part of Poland, the soil temperature at the depth of 100 mm under the perforated foil was higher by 0.8–1.0°C than under the polypropylene fibre. A higher increase in the soil temperature as a result of perforated foil use rather than by the polypropylene fibre was confirmed in the study carried out by other authors (Michaud et al. 1990, Demmler 1998). In Germany the soil temperature under the perforated foil increased by 1.8°C and under the polypropylene fibre by 1.2°C in comparison with the control object with no covering.

The occurrence times of successive plant development phases depended to a higher degree on the weather conditions. More favourable conditions for an early potato emergence were in 2002 and 2003, with a higher soil temperature in the third decade of April and in May, than in 2004 (a cold year). In those years, the full plant emergence was observed on average after 23 days from planting and in 2004 after 26 days from planting. The length of the period from seed potatoes planting to flower bud formation is nearly the same as the length of the period from seed tuber planting to tuber setting. The tuber setting was observed the earliest in the moderately warm year 2003, i.e. on average after 37 days from planting and the latest in 2002, which was a very warm season with a high rainfall shortage in the first half of May, after 40 days from planting (Tables 2 and 3). The increase in soil temperature on average by 1.9°C in the morning hours and by 3.6°C at noon hours as a result of cover use in potato cultivation for the early crop forced the plants emergence on average by 5 days and shortened the period from planting to tuber setting by 5 days compared with the cultivation with no plant covering (Tables 2 and 3). In the research carried out by other authors the perforated foil and polypropylene fibre covering shortened the period from planting to full potato emergence by 3–9 days. The plants from the covered objects were more uniform, higher, and started earlier to form flower buds and tubers (Hamouz and Rybáček 1988, Jenkins and Gillison 1995, Prośba-Białczyk and Mydlarski 1998, Sawicka and Krochmal-Marczak 2005). The plant development forced by covering depended on the weather conditions. The higher profitable effect of cover use on plant development was obtained in 2004 (the year with the lowest mean air temperature in May). The use of covers forced the plant emergence on average by 6 days and shortened the period from planting to tuber setting by 6 days. In the years with more favourable thermal conditions for potato cultivation for the early crop, the effect of the cover use was smaller (Tables 2 and 3). In long-term experiments in Czech Republic, the use of polypropylene fibre forced the emergence by 4 up to 10 days compared to the control object with no covering and forced a further growth and vegetation development in the period with less favourable climatic conditions for early potatoes (Dvořák et al. 2004, Hamouz et al. 2006).

The research did not show significant differences between the plant emergence times and tuber setting of the Aksamitka and Cykada cultivars. Only in 2002 (the highest air temperature and the lowest total rainfall in the first and second decades of May) the use of the covers resulted in higher forcing of the tuber setting by the plants of Cykada cultivar, more tolerant to the wet conditions than the Aksamitka (Table 3). The diverse reaction of the potato cultivars to the use of covers in cultivation for the early crop was confirmed in studies carried out by other authors (Prośba-Białczyk and

Table 2. Lenght of the period from seed potatoes planting to the full plant emergence (number of days)

Cultivar	Years	Control object, no covering	Type of cover		Mean for covers
			perforated foil	polypropylene fibre	
Aksamitka	2002	25.0	23.0	23.0	23.0
	2003	26.7	20.3	23.0	21.7
	2004	29.7	22.3	25.0	23.7
	mean	27.1	21.9	23.7	22.8
Cykada	2002	24.3	21.7	21.7	21.7
	2003	26.3	19.7	23.0	21.3
	2004	29.7	22.3	25.0	23.7
	mean	26.8	21.2	23.2	22.2
Mean for years	2002	24.7	22.3	22.3	22.3
	2003	26.5	20.0	23.0	21.5
	2004	29.7	22.3	25.0	23.7
Mean		26.9	21.5	23.4	22.5

LSD (P = 0.05) for: years = 1.6, comparison of the control object with the rest (contrast) = 1.1, years × contrast = 1.8, cultivars = n.s., type of cover = 1.6

Mydlarski 1998, Dvořák et al. 2004, Sawicka and Krochmal-Marczak 2005).

The present study showed a significant effect of the type of cover used on the plant development. A higher increase in the soil temperature, on average by 1–2°C, under the perforated foil rather than under the polypropylene fibre caused by 1–2 days earlier occurrence of the successive

Table 3. Lenght of the period from seed potatoes planting to tuber setting (number of days)

Cultivar	Years	Control object, no covering	Type of cover		Mean for covers
			perforated foil	polypropylene fibre	
Aksamitka	2002	43.3	38.0	40.7	39.3
	2003	40.0	36.0	36.0	36.0
	2004	43.3	36.0	38.0	37.0
	mean	42.2	36.7	38.2	37.4
Cykada	2002	44.0	38.0	38.0	38.0
	2003	40.0	36.0	36.0	36.0
	2004	43.3	36.0	38.0	37.0
	mean	42.4	36.7	37.3	37.0
Mean for years	2002	43.7	38.0	39.3	38.7
	2003	40.0	36.0	36.0	36.0
	2004	43.3	36.0	38.0	37.0
Mean		42.3	36.7	37.8	37.2

LSD (P = 0.05) for: years = 1.0, comparison of the control object with the rest (contrast) = 0.7, years × contrast = 1.2, cultivars = n.s., years × contrast × cultivar = 0.8, type of cover = 0.5, years × type of cover = 0.9

plant development phases (Tables 2 and 3). The use of the perforated foil contributed to higher forcing of the time of tuber setting on average by 2 days in 2004 (season with the lowest air and soil temperatures in April and May) compared with the previous years of study with a warmer spring.

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