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The economic effectiveness of early potato production depending on the kind of cover

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Abstract: The economic effectiveness of perforated foil and polypropylene fibre covers over different periods of plant covering (for 2 and 3 weeks after plant emergence) in early potato production was estimated. The method of incomplete calculations and marginal costs calculation were used. The economic effectiveness of production was estimated on the basis of the profitability index calculated as the ratio of yield value to direct costs. Marginal effectiveness of production under covers was calculated as the ratio of increase in production value to increase in direct costs.

The profitability index of early potato production ranged from 87.2 to 387.8% in the cultivation without covers, and from 206.6 to 359.7% in the cover-protected cultivation, depending on the year and cultivar. It was more effective to increase expenditure on production by an application of the covers under unfavourable thermal conditions in the first period of potato growth. It was more effective to increase inputs to perforated foil-protected production. Every additional 1 PLN increased the production value by 1.75 to 9.45 PLN, depending on the year and cultivar. The index of marginal effectiveness of perforated foil-protected production was over twice as high, and in the year favourable to cultivation of early potatoes it was almost the same as the index associated with polypropylene fibre-protected cultivation. The economic effectiveness of Aksamitka and Cykada production under covers was higher when plants were covered for 3 and 2 weeks after emergence, respectively.

key words: early potatoes, covers, economic effectiveness

INTRODUCTION

Production profitability of potatoes for early harvest is higher compared with other ways of usage (Chotkowski, 2001). Early potato market in Poland is relatively small and accounts for about 12% of edible potato production. Early potato production is associated with considerable risks producers have to take due to marked yield fluctuations over years and rapid price declines in response to increased supply. High incomes obtained from early potato production are possible under conditions assuring early tuber setting and rapid yield gain, which makes it possible to market produce in the period of highest prices. Location in areas where vegetation begins early has a bearing on successful early potato production (Chotkowski et al., 1995; Rembeza, 1995). In areas characterised by less favourable weather conditions, harvest of new potato tubers can be accelerated by applying perforated foil or polypropylene fibre covers (Demmler, 1998; Prośba-Białczyk, Mydlarski, 1998; Pszczółkowski, Sawicka, 2003; Dvořák et al., 2004; Wadas et al., 2007). Such production method requires higher inputs incurred whereas the production effect resulting from increased tuber yields, compared with non-covered cultivation, depends on weather conditions over the potato growing season (Prośba-Białczyk et al., 1997; Pszczółkowski et al., 2000/2001; Wadas, 2003; Harasim et al., 2004). Increasing production inputs is effective if the value of yield increase obtained is higher than the costs incurred (Rembeza, 2002).

The aim of the study was to evaluate economic effectiveness of an application of perforated foil and polypropylene fibre covers in early potato production in the region of southern Podlasie characterised by less favourable spring weather conditions for potato grown for early harvest. The studies were initiated to collect information on possibilities of reducing risks associated with early potato cultivation in the region, and improving production effectiveness due to an appropriate choice of cover kind and length of plant covering period.

MATERIALS AND METHODS

A field experiment was carried out at the Experimental Station in Zawady near Siedlce, southern Podlasie, in the years 2002–2004. An effect of cover kind (perforated foil,

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polypropylene fibre) and the length of plant covering period (for 2 and 3 weeks after plant emergence) on economic effectiveness of early potato production was investigated. The field experiment was established in the split-block-split-plot design with a non-covered control treatment on podzolic soil. Seed tubers of cv Aksamitka and Cykada were pre-sprouted for 8 weeks and then planted on the 9th, 16th and 13th of April in successive study years. The area of one plot was 15 m^2. Cultivation was performed according to the general agronomic practices. Potato tubers were harvested after about 60 days from planting.

Economic effects of covering in early potato production were evaluated on the basis of comparisons made between the values of yield obtained and respective levels of costs incurred. The method of incomplete calculations as well as marginal cost calculus were applied in the work. The cost of purchasing perforated foil and polypropylene fibre cover were divided by 3 years as, when appropriately used and stored, they can be utilised for three consecutive growing seasons. The calculations were based on marketable tuber yield (tuber diameter over 28 mm) and market prices of one kilogram of new potatoes which in 2002, 2003 and 2004 were 1.80, 2.00 and 1.70 PLN, respectively. Direct costs were calculated based on the prices in the study years. The method of calculations was described in detail in the work by Wadas et al. (2006). Economic effectiveness of production was evaluated on the basis on the profitability index (index of costs productiveness) computed as a percentage ratio of yield obtained and direct costs incurred. The index does not reflect actual, overall profitability of production due to not including indirect costs. However, it assures comparability of results. Final effectiveness of cover-protected production was calculated as a ratio of production value increase to direct costs increase.

Favourable thermal conditions for early-harvested potato cultivation prevailed in 2002 only. In the year 2003, due to a very cold first half of April, with occasional snowfall, it was not possible to plant potatoes early. However, higher temperatures in May and June, compared with the long-term mean for the study region, created good conditions for rapid yield increase. Moreover, in 2003 potato growth and development was curtailed by drought over the whole of the growing season. In turn, the year 2004 was very cold and wet. Marketable tuber fraction yield from non-covered cultivation in years with warm and cold spring ranged from, respectively, 7.85 to 10.45 t ha^{-1} and 3.18 to 3.89 t ha^{-1}, depending on the cultivar. Compared with non-covered cultivation, an application of covers increased yields from 1.75–7.11 t ha^{-1} in warmer years to 9.57–14.95 t ha^{-1} in the year with cold spring (Wadas et al., 2007).

RESULTS AND DISCUSSION

Economic effectiveness of accelerated early potato production under covers depends on the income-costs incurred relations. Yield value from non-covered production ranged from 5406.0 PLN ha^{-1} to 20900.0 PLN ha^{-1}, according to the study year and cultivar (Table 1). An application of covers increased the production value by 3490.0 to 25415.0 PLN ha^{-1} (17.6 to 395.1%). The highest increase in the value of cover-protected production was obtained in 2004 characterised by the lowest air temperature in the initial period of potato growth. When perforated foil and polypropylene fibre cover were used, the value of yield obtained was respectively almost 5 and 3.7 times higher compared with non-covered cultivation. In 2002 and 2003, when springs were warmer, the effect of covering – in terms of an increase in production value – was lower compared with non-covered cultivation, and amounted to 31.7 and 26.0%, respectively, when perforated foil was used, and 69.1 and 19.5%, respectively, when polypropylene fibre cover was applied. In the warmest growing season of 2002, the value of polypropylene fibre-protected potato production was higher, on average by 5931.0 PLN ha^{-1} (28.4%), compared with perforated foil. In the remaining study years the production value of perforated foil-protected potato was higher (Table 1). Covering increased Aksamitka yields more than Cykada yields. When averaged across all three years, Aksamitka yield value was by 89.4% higher when perforated foil was used, and by 92.1% greater when polypropylene fibre cover was utilised, compared with non-covered cultivation. An increase in Cykada tuber production value resulting from covering of plants was, respectively, 77.0 and 64.4%. The yield value of Aksamitka was higher when the plants were covered for 3 weeks after emergence, whereas for Cykada the covering period was by one week shorter to obtain the same yield value (Table 1).

Covering applied in early potato production is associated with higher inputs incurred. In the present study the direct costs of non-covered early potato production ranged from 5130.9 to 6214.3 PLN ha^{-1}, according to the study year and cultivar (Table 2). An application of perforated foil and polypropylene fibre cover increased the direct costs of production by 2088.8–2686.5 PLN ha^{-1} (39.8–46.2%), and 3913.3–4337.2 PLN ha^{-1} (69.7–82.3%), respectively. Covering of potato plants grown in the Wrocław region with polypropylene fibre increased direct costs of early potato production 82.8–92.5% compared with non-covered cultivation (Prośba-Białczyk et al., 1997). In turn, perforated foil-protected production costs in the Olsztyn region were by 23.8–29.1% higher (Wierzbicka, 1995). Similar results were obtained in the Lublin region where covering with either perforated foil or polypropylene fibre cover increased direct costs of production by 26.7–32.1% (Pszczółkowski et al., 2000/2001). An increase in early potato production costs was much smaller when polypropylene fibre cover was applied in the Lublin region versus other Polish regions. It was due to the fact that the cover was continuously utilised for 5 growing seasons. German studies showed

Table 1

Yield value (PLN ha^{-1}).

Years	Cultivar	No covering	Kind and date of cover removal					
			perforated foil			polypropylene fibre		
			I	II	mean	I	II	mean
2002	Aksamitka	14130.0	20538.0	20232.0	20385.0	23652.0	30222.0	26937.0
	Cykada	17568.0	23868.0	18846.0	21357.0	30348.0	22986.0	26667.0
	mean	15849.0	22203.0	19539.0	20871.0	27000.0	26604.0	26802.0
2003	Aksamitka	15940.0	20160.0	19840.0	20000.0	18980.0	19880.0	19430.0
	Cykada	20900.0	27680.0	25120.0	26400.0	24740.0	24420.0	24580.0
	mean	18420.0	23920.0	22480.0	23200.0	21860.0	22150.0	22005.0
2004	Aksamitka	5406.0	25160.0	28475.0	26817.5	19125.0	24412.0	21768.5
	Cykada	6613.0	34833.0	29223.0	32028.0	26673.0	19074.0	22873.5
	mean	6009.5	29996.5	28849.0	29422.7	22899.0	21743.0	22321.0

Date of cover removal: I – 2 weeks after plant emergence, II – 3 weeks after plant emergence.

Table 2

Direct costs of early potatoes production (PLN ha^{-1}).

Years	Cultivar	No covering	Kind and date of cover removal					
			perforated foil			polypropylene fibre		
			I	II	mean	I	II	mean
2002	Aksamitka	5130.9	7503.0	7497.5	7500.3	9316.5	9389.0	9352.8
	Cykada	5251.9	7378.5	7302.8	7340.7	9214.0	9116.3	9165.2
	mean	5191.4	7440.8	7400.2	7420.5	9265.3	9252.7	9259.0
2003	Aksamitka	5359.8	7681.2	7664.3	7672.7	9421.1	9213.4	9317.2
	Cykada	5389.1	7775.4	7739.8	7757.6	9496.6	9495.4	9496.0
	mean	5374.4	7728.3	7702.1	7715.2	9458.8	9354.4	9406.6
2004	Aksamitka	6201.8	8827.8	8864.0	8845.9	10482.2	10567.1	10524.6
	Cykada	6214.3	8931.4	8870.2	8900.8	10620.8	10482.2	10551.5
	mean	6208.1	8879.6	8867.1	8873.4	10551.5	10524.6	10538.1

Explanations see Table 1.

that yearly costs of using both covers are similar when perforated foil and polypropylene fibre cover were used 1.5–2 times and 2–2.5 times, respectively (Demmler, 1998).

Studies carried out in the Wrocław and Lublin regions demonstrated that an application of covers makes it possible to markedly increase incomes derived early potato production (Prośba-Białczyk et al., 1997; Pszczółkowski et al., 2000/2001; Harasim et al., 2004), which was also confirmed in the present study. Under the conditions of the current study the value of non-covered production exceeded the costs incurred only in the years 2002 and 2003 when springs were warmer. Moreover, the direct surplus depended on the cultivar and ranged from 8999.1 PLN ha^{-1} to 15510.9 PLN ha^{-1} (Table 3). In 2004, which was very unfavourable to early potato production, yields were very low, which resulted in the production value being lower than the costs associated with it. As far as cover-protected production is concerned, in all the study years the value of production was higher than the costs incurred, and produced a surplus. Covering resulted in an almost twofold higher direct surplus, when averaged across three years, compared with non-covered production. In the studies in the Lublin region, a higher surplus of production value was obtained when polypropylene fibre cover was applied, compared with perforated foil (Pszczółkowski et al. 2000/2001; Harasim et al., 2004). In the present study, a production value surplus which exceeded costs incurred was associated with polypropylene fibre cover only in the year 2002 when the spring was warmer (Table 3). Compared with perforated foil, polypropylene fibre covering made it possible to obtain a direct surplus value which was higher by an average of 4092.5 PLN ha^{-1} (30.4%). When the conditions were less favourable to potato production, a higher direct surplus was obtained when perforated foil was applied to protect potatoes. In 2004, characterised by cold spring, the direct surplus associated with perforated foil covering was on average by 8766.5 PLN ha^{-1} (74.4%) higher compared with polypropylene fibre cover. Kind of cover more significantly influenced the direct surplus associated with the cultivation of Cykada versus Aksamitka. Ir-

Table 3

Direct surplus from early potatoes production (PLN ha^{-1}).

Years	Cultivar	No covering	Kind and date of cover removal					
			perforated foil			polypropylene fibre		
			I	II	mean	I	II	mean
2002	Aksamitka	8999.1	13035.0	12734.5	12884.7	14335.5	20833.0	17584.2
	Cykada	12316.1	16489.5	11543.2	14016.3	21134.0	13869.7	17501.8
	mean	10657.6	14762.2	12138.8	13450.5	17734.7	17351.4	17543.0
2003	Aksamitka	10580.2	12478.7	12175.7	12327.3	9558.9	10666.6	10112.8
	Cykada	15510.9	19904.6	17380.2	18642.4	15243.4	14924.6	15084.0
	mean	13045.6	16191.7	14777.9	15484.8	12401.2	12795.6	12598.4
2004	Aksamitka	-795.8	16332.2	19611.0	17971.6	8642.8	13844.9	11243.8
	Cykada	398.7	25901.6	20352.8	23127.2	16052.2	8591.8	12322.0
	mean	-198.6	21116.9	19981.9	20549.4	12347.5	11218.4	11782.9

Explanations see Table 1.

Table 4

Profitability index of early potatoes production (%).

Years	Cultivar	No covering	Kind and date of cover removal					
			perforated foil			polypropylene fibre		
			I	II	mean	I	II	mean
2002	Aksamitka	275.4	273.7	269.8	271.8	253.9	321.9	287.9
	Cykada	334.1	323.5	258.1	290.8	329.4	252.1	290.8
	mean	305.0	298.6	264.0	281.3	291.6	287.0	289.3
2003	Aksamitka	297.4	262.5	258.9	260.7	201.5	215.8	208.6
	Cykada	387.8	356.0	324.6	340.3	260.5	257.2	258.8
	mean	342.6	309.2	291.7	300.5	231.0	236.5	233.7
2004	Aksamitka	87.2	285.0	321.2	303.1	182.4	231.0	206.7
	Cykada	106.4	390.0	329.4	359.7	251.1	182.0	216.6
	mean	96.8	337.5	325.3	331.4	216.8	206.5	211.6

Explanations see Table 1.

respective of the kind of cover, a higher surplus of production value for Aksamitka and Cykada was recorded when the covering period was, respectively, 3 and 2 weeks after plant emergence (Table 3).

The profitability index of early potato cultivation ranged from 87.2 to 387.8%, and 206.7 to 359.7% for, respectively, non-covered and cover-protected production (Table 4). In 2002 and 2003, when the conditions favoured potato growth, a production value increase due to covering was not large and, as a result, production profitability was lower compared with non-covered cultivation. The year 2004 was the least favourable to early potato cultivation and the profitability index of cover-protected production calculated for this year was on average by almost threefold higher compared with non-covered production. Profitability of non-covered and cover-protected production in 2002, the year with warm spring, was similar. In turn, in 2003 and 2004, which were characterised by worse thermal conditions in April, higher profitability was associated with perforated foil; the profitability index for this cover was, respectively, by 1.3 and 1.6 times higher compared with polypropylene fibre cover. Studies conducted in the Lublin region demonstrated that early potato production including polypropylene fibre covering was more profitable than perforated foil-protected cultivation (Pszczółkowski et al., 2000/2001; Harasim et al., 2004). Differences in the results may follow from the fact that the study in the Lublin area was based on a three-year period of perforated foil utilisation and a five-year period of polypropylene fibre cover use.

The study discussed showed that increased inputs to early potato production in the region of southern Podlasie were effective when covers were applied over periods of less favourable weather conditions (Tables 5 and 6). In all the study years, the value of additional yield obtained in perforated foil-protected cultivation covered the cost of foil application and produced a surplus. Every 1 PLN additionally spent on production yielded the production value increase of 1.75–9.45 PLN, according to the study year and cultivar. A 1 PLN increase in costs caused a 0.88–3.78 PLN increase in production value when polypropylene fibre-covering was used. The use of this cover was economically viable in two growing seasons only as 1 PLN of additional costs resulted in the production value increase of more than

Table 5

Economic effectiveness of perforated foil covers used in early potato production.

Specification	Cultivar	Years and date of cover removal								
		2002			2003			2004		
		I	II	mean	I	II	mean	I	II	mean
Value of additional tuber yield (PLN ha^{-1})	Aksamitka	6408.8	6102.0	6255.0	4220.0	3900.0	4060.0	19754.0	23069.0	21411.5
	Cykada	6300.0	1278.0	3789.0	6780.0	4220.0	5500.0	28220.0	22610.0	25415.0
	mean	6354.0	3690.0	5022.0	5500.0	4060.0	4780.0	23987.0	22829.5	23413.2
Increase in production costs (PLN ha^{-1})	Aksamitka	2372.1	2366.6	2369.4	2321.4	2304.5	2313.0	2626.0	2662.2	2644.1
	Cykada	2126.6	2050.9	2088.8	2386.3	2350.7	2368.5	2717.1	2655.9	2686.5
	mean	2249.4	2208.8	2229.1	2353.9	2327.7	2340.8	2671.5	2659.0	2665.3
Marginal effectiveness	Aksamitka	2.70	2.58	2.64	1.81	1.69	1.75	7.52	8.66	8.09
	Cykada	2.96	0.62	1.79	2.84	1.80	2.32	10.39	8.51	9.45
	mean	2.83	1.60	2.22	2.33	1.74	2.03	8.95	8.59	8.77

Explanations see Table 1.

Table 6

Economic effectiveness of polypropylene fibre covers used in early potato production.

Specification	Cultivar	Years and date of cover removal								
		2002			2003			2004		
		I	II	mean	I	II	mean	I	II	mean
Value of additional tuber yield (PLN ha^{-1})	Aksamitka	9522.0	16092.0	12807.0	3040.0	3940.0	3490.0	13719.0	19006.0	16362.5
	Cykada	12780.0	5418.0	9099.0	3840.0	3520.0	3680.0	20060.0	12461.0	16260.5
	mean	11151.0	10755.0	10953.0	3440.0	3730.0	3585.0	16889.5	15733.5	16311.5
Increase in production costs (PLN ha^{-1})	Aksamitka	4185.6	4258.1	4221.8	4061.3	3853.6	3957.4	4280.4	4365.3	4322.8
	Cykada	3962.1	3864.4	3913.2	4107.5	4106.3	4106.9	4406.5	4267.9	4337.2
	mean	4073.9	4061.3	4067.5	4084.4	3980.0	4032.2	4343.4	4316.5	4330.0
Marginal effectiveness	Aksamitka	2.28	3.78	3.03	0.75	1.02	0.88	3.20	4.35	3.78
	Cykada	3.23	1.40	2.31	0.94	0.86	0.90	4.55	2.92	3.74
	mean	2.75	2.59	2.67	0.84	0.94	0.89	3.88	3.64	3.76

Explanations see Table 1.

1 PLN. Under conditions favouring the growth of potato plants, the index of marginal effectiveness of polypropylene fibre-protected production was on average by 1.2 times higher compared with perforated foil. When weather conditions were worse for initial growth and development of potato plants, it was more effective to increase inputs to production by means of perforated foil covering; the index of marginal effectiveness of perforated foil-protected production was then over twofold higher. Analysis of marginal costs of covering in accelerated early potato production in the Lublin region revealed that it was more effective to increase inputs by applying polypropylene fibre covers (Harasim et al., 2004). Under the conditions of the present study only in 2004, when the spring was cold, the index of marginal effectiveness of cover-protected early potato production was higher compared with the index of average costs effectiveness (Tables 4-6). In the above year the index of marginal effectiveness of production using perforated foil and polypropylene fibre cover was, respectively, by 2.6 and 1.8 times higher on average, compared with the index of average costs effectiveness. High economic effectiveness of early potato production including polypropylene fibre cover was reported in earlier studies carried out in the same region which, however, used different potato cultivars.

Application of covers in accelerated early potato production may be more profitable when combined with an appropriate choice of cultivars (Wierzbicka, 1995; Pszczółkowski et al., 2000/2001; Wadas, 2003), which was also supported in the present study. Regardless of the cultivation method, higher production profitability was found for Cykada (Table 4). Cultivation of Aksamitka and Cykada was associated with higher effectiveness of marginal costs of, respectively, perforated foil and polypropylene fibre covers. Regardless of the cover kind, effectiveness of marginal costs associated with covering of Aksamitka and Cykada was higher when plants were covered for, respectively, 3 and 2, weeks after emergence (Tables 5 and 6).

CONCLUSIONS

1. Increased inputs on cover-protected production was more effective when weather conditions were less favourable in the initial period of potato growth. A substantial increase in tuber yield of cover-protected potato resulted in higher effectiveness of marginal costs compared with average costs effectiveness.

2. It was more effective to increase production inputs by means of perforated foil. The index of marginal effectiveness of perforated foil-protected production was over twofold higher and, in the year which was very good for early potato cultivation, almost the same as the index associated with polypropylene fibre cover.

3. Economic effectiveness of marginal costs of covering in Aksamitka and Cykada cultivation was higher when plants were covered for, respectively, 3 and 2 weeks after emergence.

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