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AN ECONOMIC ASSESSMENT OF DIFFERENT FERTILIZATION SYSTEMS IN THE CULTIVATION OF POTATO FOR INDUSTRIAL PROCESSING

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Abstract. This paper presents calculations based on results of a field experiment, in which selected potato cultivars grown for industrial processing received different fertilization. The data originated from trials on three potato cultivars: Adam, Pasja Pomorska and Ślęza, at set up at the Research Station in Bałcyny, owned by the University of Warmia and Mazury in Olsztyn, and completed in 2008-2010. The economic analysis included planned and performed treatments as well as such information as the type of technical equipment, labour and draught force input, or material outlays. Based on the analysis, it can be concluded that the three starch potato cultivars responded differently to foliar fertilization. The cv. Pasja Pomorska yielded the highest under soil fertilization with 280 kg·ha^{-1} NPK (80 N, 80 P, 120 K) and foliar application of Basfoliar 12-4-6 in a dose of 8 dm^3·ha^{-1}. Considering the ratio of the yields to costs, cv. Ślęza was characterized by the best profitability index, which in every technological variant reached a value of over 2.0. From the point of view of rational economy, the most profitable was the fertilization combination which consisted of soil fertilization with 420 kg·ha^{-1} NPK (120 N, 144 P, 156 K) and foliar application of Basfoliar 12-4-6 with Solubor DF in amounts of 4 + 1 dm^3·ha^{-1}.

Key words: costs of production, disease protection, foliar fertilization, production profitability, starch potato, value of production

INTRODUCTION

Potato plays an important role in human nutrition and finds a variety of other uses. The consumption of potatoes in Poland is 101 kg per capita annually, being up to 50% higher than in most EU countries, although it is expected to drop to 97 kg per capita [Rynek ziemniaka 2015]. Potatoes are a versatile crop, used as food, feed and raw

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material for industry. Depending on the use, potato cultivars should have specific characteristics, such as: chemical composition (the content of dry matter, starch, protein, mineral salts, vitamins, sugar, etc.), shape of tubers, the setting of potato eyes, colour of the flesh, taste and many other properties. Noteworthy are the increasingly more stringent requirements which potatoes are expected to meet, which means that potato growers must adjust their production to satisfy consumer demands. The situation is even more difficult due to large production volume and price fluctuations. For instance high potato yields harvested in 2014 caused a lasting decline in prices, with a substantial impact on profitability [Rembeza 2015]. Despite the low prices in 2015, the total acreage cropped with potatoes in Poland was estimated to have covered 308,000 ha, which was 11% higher than in the preceding year [Rynek ziemniaka 2015]. In terms of yields, just 20 tons per ha were harvested in 2015, whereas the record high yields in 2014 reached 27.9 t per ha [Rynek ziemniaka 2015]. Potato cultivation is an expensive and labour-consuming branch of farming, which means that inputs per unit area are much higher than in any other type of plant growing [Chotkowski 2000]. Hence, it is extremely important to ensure high yields, which increase production and economic outputs [Gugała and Zarzecka 2008]. A key to successful commercial potato cultivation is also the right scale of production, but potato fields in Poland are fragmented and scattered, which impedes more efficient organization that could reduce production costs. Growing potatoes on small fields generates the poorest economic results [Nowacki 2009, Rynek ziemniaka 2013].

The profitability of potato production is strongly affected by the type of use for which potatoes are grown, which determines the prices earned. Table 1 illustrates changes in the distribution of potato yields in Poland. Over the last ten years, there have been significant changes in all distribution directions. Quantities of potatoes used for animal feeds have declined significantly while more potatoes have been sold for human consumption or industrial processing. For years, the cultivation of starch potato has been on the margin of proftability [Chotkowski 2010], even though the Regulation of the Minister for Agriculture and Development of Rural Areas issued on 7 November 2014 set starch subsidies at 351.69 PLN·ha^{-1} of potato starch [Rozporządzenie Ministra … 2014].

Table 1. Distribution of domestic potato production, %

Use							
season	losses	planting	animal feeds	self-supply	sold for consumption	industrial processing	export
2005/2006	11.0	10.6	35.3	12.4	19.0	11.5	0.2
2015/2016	7.7	8.6	15.2	15.6	26.9	25.2	0.8

source: Rynek ziemniaka. Stan i perspektywy. Analizy rynkowe 2015: IERiGŻ-PIB, ARR, MRiRW, Warszawa, 42, 19-26

Potato production requires very special farming, which involves numerous agrotechnical treatments that ought to be performed with utmost care and precision. However, the fundamental decision a farmer must make is potato yields will be utilized and what requirements they will have to satisfy. Potato buyers are guided by both the selling price and the required parameters of potatoes, hence potato growers must strive at quality while keeping the costs low.

The purpose of this study has been to make an economic assessment of different cultivars of starch potato fertilization systems.

MATERIAL AND METHODS

In 2008-2010, field experiments were conducted by the staff of the Department of Agrotechnology, Agriculture Management and Agribusiness, University of Warmia and Mazury in Olsztyn. The field was located at the Research Station in Bałcyny (53^{o}35′ N; 19^{o}51′ E). Three-factorial replicable trials (repeated in subsequent years) were set up in a randomized split-split-plot design with three replications, on grey-brown podsolic soil developed from boulder clay.

The following factors were considered:

– the first experimental factor was a potato cultivar: Adam (a medium-early cultivar with an average starch content of 18.5%), Pasja Pomorska (a medium-late cultivar with an average starch content of 20%), and Ślęza (late cultivar with a high starch content of 21.5%). The cultivars Pasja Pomorska and Ślęza are preferred for starch production in Poland;
– the second factor comprised two levels of soil fertilization: A – 280 NPK kg·ha^{-1} (80 N, 80 P, 120 K – in pure chemical elements), B – 420 kg·ha^{-1} NPK (120 N, 144 P, 156 K – in pure chemical elements). Soil fertilization involved a single application of potash salt (60%), granular triple superphosphate (46%) and ammonium nitrate (34%) before potato planting.

The third factor was foliar fertilization: a – Basfoliar 2-4-6 (8 dm^3·ha^{-1}), b – ADOB Mn (4 dm^3·ha^{-1}), c – Solubor DF (2 dm^3·ha^{-1}), d – ADOB Mn + Solubor DF (2 + 1 dm^3·ha^{-1}), e – ADOB Mn + Basfoliar 12-4-6 (2 + 4 dm^3·ha^{-1}), f – Basfoliar 12-4-6 + Solubor DF (4 + 1 dm^3·ha^{-1}), g – Basfoliar 12-4-6 + ADOB Mn + Solubor DF (2.7 + 1.3 + 0.7 dm^3·ha^{-1}), h – control treatment – no foliar fertilization. Foliar fertilizers were applied once, at the beginning of flowering (BBCH 61). The composition of foliar fertilizers was as follows (% by weight): ADOB® Mn: Mn – 10.0, N – 6.5, Mg – 2.0; Solubor® DF: B – 17.5; Basfoliar® 12-4-6: N – 12.0, P_2O_5 – 4.0, K_20 – 6.0, MgO – 0.2, Mn – 0.01, Cu – 0.01, Fe – 0.01, B – 0.02, Zn – 0.005, Mo – 0.005.

Potatoes were planted in the 3rd decade of April. Tubers (certified material, class CA) were planted 40 cm apart from one another, in rows set at 62.5 cm. The total planting density was 40,000 potato plants per hectare. Each year, potato was grown on a field cropped with cereals in the preceding season, which did not receive organic fertilization. Potatoes were harvested at full maturity, in the third decade of September. Cultivation measures included double earthing up and several sprays of pesticides. Dicotyledonous weeds were controlled by the herbicide Afalon Flowable 450 S.C. in a dose of 2 dm^3·ha^{-1}. Potato blight was prevented by using fungicides producing systemic effects, such as Ridomil Gold MZ 68 WG 2 kg·ha^{-1} and Tattoo C 750 SC 2 dm^3·ha^{-1}, and – on a later date – preparations producing topical action, such as Antracol 70 WG 1.8 kg·ha^{-1} and Gwarant 500 SC 2 dm^3·ha^{-1}. Colorado potato beetles were eradicated with neonocotinoids Apacz 50 WG 40 g·ha^{-1}, Calypso 480 SC 0.08 dm^3·ha^{-1} and Mospilan 20 SP 80 g·ha^{-1}.

All calculations were made in line with the Polish agricultural accounting guidelines [Goraj 2000], including the classical division into direct and indirect costs, which enabled us to calculate basic costs and revenues according to the following scheme [Augustyńska-Grzymek *et al.* 2008]:

1) Value of Production (*VoP*),
2) Direct Costs (*DC*),
3) Direct Margin (*DM*),
4) Indirect Costs (*IC*),
5) Agricultural Income (*AI*),
6) Total Costs (*TC*),
7) Unit Production Cost (*UPC*).

In addition, the following were caclulated:

Gross Margin Ratio

$$GMR = \frac{DM}{VoP} 100\%$$

Profit Rate

$$PR = \frac{AI}{VoP} 100\%$$

Production Profitability Index

$$PPI = \frac{VoP}{TC}$$

Relative Costs Index

$$RCI = \frac{TC}{VoP}$$

Unit costs of tractors and machines as well as costs of performing individual agrotechnical treatments were calculated according to the methodology used at the Institute of Agricultural Constructions, Mechanisation and Electrification in Warsaw [Muzalewski 2007].

The main criterion underlying our analysis consisted of the three-year mean yields. The results underwent statistical processing, applying analysis of variance. The Tukey's test was run to assess differences between treatments, at the probability of error p = 0.05. All analyses were supported by the software Statistica 10®.

RESULTS AND DISCUSSION

The research results have revealed substantial differences between the three potato cultivars in their response to foliar and soil fertilization variants. Table 2 contains the data on tuber yields and deviation from the control yield. The highest yields were produced by cv. Pasja Pomorska in soil fertilization variant A – 280 $kg \cdot ha^{-1}$ NPK (80 N, 80 P, 120 K) combined with each foliar fertilization system. These tuber yields exceeded 40 $Mg \cdot ha^{-1}$. Among the three potato varieties, the highest yield increase was achieved by cv. Pasja Pomorska (nearly 2 $Mg \cdot ha^{-1}$) grown in soil fertilization variant A – 280 $kg \cdot ha^{-1}$ NPK (80 N, 80 P, 120 K) with the foliar application of Basfoliar 12-4-6 (8 $dm^3 \cdot ha^{-1}$). The cultivar Ślęza grown in the same technological system responded similarly, but the tuber yield increment was smaller and equalled 1.3 $Mg \cdot ha^{-1}$.

In general, soil fertilization variant B composed of 420 $kg \cdot ha^{-1}$ NPK (120 N, 144 P, 156 K) led to a yield decrease, which was most severe in the case of cv. Ślęza. The yield produced by this potato variety declined by 1.12 $Mg \cdot ha^{-1}$ in foliar fertilization variant a, and dropped by 1.04 $Mg \cdot ha^{-1}$ in variant b. The cultivar Pasja Pomorska responded similarly, but the highest yield decrease occurred in the variant with foliar fertilization b – ADOB Mn (4 $dm^3 \cdot ha^{-1}$), where it reached 1.19 $Mg \cdot ha^{-1}$.

Table 2. Agricultural efficiency of the tested technologies of growing starch potato cultivars

Specification Mg·ha^{-1}	Soil fertilization variants	Foliar fertillization variants*							
		a	b	c	d	e	f	g	h
					Adam				
Tuber field	A	32.03	31.79	30.86	31.71	31.32	32.02	31.23	31.71
Tuber yield increase**		0.08	0.32	-0.85	-0.85	0	-0.39	0.31	–
Tuber field	B	33.64	33.62	34.87	35.26	33.7	34.55	35	34.33
Tuber yield increase**		-0.69	-0.71	0.54	0.93	-0.63	0.22	0.67	–
					Pasja Pomorska				
Tuber field	A	41.47	40.04	40.41	40.35	39.79	39.8	40.23	39.48
Tuber yield increase**		1.99	0.56	0.93	0.87	0.31	0.32	0.75	–
Tuber field	B	39.89	39.15	39.8	40.44	39.64	39.31	40.09	40.34
Tuber yield increase**		-0.45	-1.19	-0.54	0.1	-0.7	-1.03	-0.25	–
					Ślęza				
Tuber field	A	38.89	37.38	38.28	38.1	38.42	38.26	37.74	37.59
Tuber yield increase**		1.3	-0.21	0.69	0.51	0.83	0.67	0.15	–
Tuber field	B	38.64	38.72	39.07	39.99	38.96	39.56	39.68	39.76
Tuber yield increase**		-1.12	-1.04	-0.69	0.23	-0.8	-0.2	-0.08	–

* description in Material and Methdos; ** relative to foliar fertillization variant h
source: the authors, based on the experiment results

Potato production is characterized by high labour inputs of tractors and machines. The work input equal 16 hours per 1 ha (Table 3) needed to grow potatoes is about four-fold higher than required, for example, in winter triticale cultivation [Dubis *et al*. 2015]. Such high consumption of labour is due to the high inputs of work to harvest and transport large masses of tubers. In our experiment, the total cost of the work done by tractors and machines was over 1550 PLN·ha^{-1}, which corresponded to nearly 70% of the costs of all performed work. Compared to the costs of agricultural machinery use in Germany, which are around 30% of total outlays, this is a substantial percentage [Beratungsinitiative 2011]. The costs incurred by deep ploughing and planting are specific for potato cultivation, while the costs of other agrotechnical measures do not diverge much from corresponding costs in cultivation of other crops. However, it needs to be added that potatoes grown on heavier soils can have a higher starch content [Wölfel 2009], but their cultivation generates additional costs due to a heavier load put on machines. Also, irrigation of potato fields can improve yields considerably [Fricke 2004, Winkelmann 2003] but is rarely done in Poland because it is costly.

Table 4 comprises detailed calculations of the costs of technologies and the results achieved by the analyzed starch potato varieties. This specification also includes variants of soil fertilization. The total costs equalled 7342 PLN·ha^{-1} for growing cv. Ślęza and the lowest ones were 6341 PLN·ha^{-1}. These are relatively high production costs, which translate into the poor competitiveness of Polish potatoes [Jerchel *et al.* 2014]. Other countries, e.g. Israel, are much more competitive, because their potato production costs do not exceed 1000 Euro·ha^{-1} including the cost of field irrigation [Moritz 2015].

Table 3. Costs associated with tractor and machine operation in the analyzed production systems of different potato cultivars

Foliar fertillization variants*	Type of activity	Unit cost of work, PLN^{-1}			Number of working hours $h \cdot ha^{-1}$	Tractor and machine work value, $PLN \cdot ha^{-1}$
		traktor	machines	tractor + machines		
a-h	skimming	114.8	7.8	122.5	0.5	61.3
	harrowing	50.4	3.4	53.8	0.3	13.5
	deep ploughing	128.1	39.5	167.6	1.3	217.8
	NPK fertilization	50.4	4.5	54.9	0.2	11.0
	cultivator	146.7	45.0	45.0	0.7	31.5
	potato planting	102.4	28.6	131.0	1.4	183.4
	earthing up x 2	50.4	4.6	55.0	1.2	66.0
	sprays with microelements	83.8	18.5	102.3	0.2	15.3
	herbicide spray	83.8	18.5	102.3	0.2	15.3
	insecticide spray x 2	83.8	18.5	102.3	0.3	30.7
	fungicide spray x 2	83.8	18.5	102.3	0.3	30.7
	harvest	146.7	51.3	198.0	5.0	989.8
	transportation	102.4	22.8	125.2	4.5	563.3
	Σ	–	–	–	16.0	**2229.6**

* description in Material and Methods
source: the authors, based on the experiment results

The highest profitability index was scored by cv. Ślęza: 2.0 under soil fertilization system A – 280 $kg \cdot ha^{-1}$ NPK (80 N, 80 P, 120 K) and 1.9 when variant B – 420 $kg \cdot ha^{-1}$ NPK (120 N, 144 P, 156 K) was applied. The poorest results were obtained when growing the potato variety Adam, which in both soil fertilization variants achieved the profitability index of 1.4. Moreover, the unit cost of growing cv. Adam was the highest in variant A, where it reached 200 PLN $PLN \cdot ha^{-1}$ Mg, which was over 40 PLN more than the lowest unit cost.

Based on the results of our field trials, profitability indices for individual soil and foliar fertilization variants were calculated (Table 5). Same as above, cv. Ślęza achieved the best results. The profitability indices computed for this potato cultivar were considerably higher than for the other two varieties. For cv. Ślęza, the most effective soil and foliar fertilization system was the one designated as variant B + f, i.e. respectively B – 420 $kg \cdot ha^{-1}$ NPK (120 N, 144 P, 156 K), f – Basfoliar 12-4-6 + Solubor DF (4 + 1 $dm^3 \cdot ha^{-1}$). The profitability index calculated for cv. Ślęza in this variant was 2.24. Again, the indices derived for cv. Adam were very low, and the lowest index value was calculated for this potato cultivar grown in variant A + c (1.39), namely A – 280 $kg \cdot ha^{-1}$ NPK (80 N, 80 P, 120 K), c – Solubor DF (2 $dm^3 \cdot ha^{-1}$).

The three analyzed cultivars differed in the values of tuber yields, which are determined by the prices obtained on the market. Table 6 shows calculations concerning a gain or loss in the value of yield compared with the control (with no foliar ferilization). The collected data suggest that the highest yield value increase was achieved by cv. Pasja Pomorska (537 $PLN \cdot ha^{-1}$) in fertilization variant A + a at the level of soil fertilization A – 280 $kg \cdot ha^{-1}$ NPK (80 N, 80 P, 120 K) and foliar fertilization a – Basfoliar 12-4-6 (8 $dm^3 \cdot ha^{-1}$). The smallest production efficiency, manifested by a decreasing yield value versus the control, was found for cv. Ślężą grown in fertilization variant B + a at the soil fertilization level B – 420 kg·ha^{-1} NPK (120 N, 144 P, 156 K) and foliar fertilization Basfoliar 12-4-6 (8 dm^3·ha^{-1}).

Table 4. Costs of production technologies used for growing the selected potato cultivars, PLN·ha^{-1}

Specification	Cultivar							
	Adam		Pasja Pomorska		Ślęza		Mean	
Soil fertilization variants	A	B	A	B	A	B	A	B
Value of production	8964.7	9670.6	11829.0	11729.1	13503.7	13863.6	11358.1	11690.8
Field, Mg·ha^{-1}	31.6	34.4	40.2	39.8	42.5	43.7	38.1	39.3
Value of field	7989.7	8695.6	10854.0	10754.1	12528.7	12888.6	10383.1	10715.8
Direct subsidies	975.0							
Starch subsidies	in the price							
Direct costs in total	3453.0	3914.0	3669.0	4130.0	3993.0	4454.0	3435.0	4166.0
Planting material	2052.0	2052.0	2268.0	2268.0	2592.0	2592.0	2304.0	2304.0
Mineral fertilzation	857.0	1318.0	857.0	1318.0	857.0	1318.0	587.0	1318.0
Ammonium nitrate (34%)	286.0	430.0	286.0	430.0	286.0	430.0	286.0	430.0
Granular triple superphosphate (46%)	280.0	505.0	280.0	505.0	280.0	505.0	280.0	505.0
Potash salt (60%)	291.0	383.0	291.0	383.0	291.0	383.0	291.0	383.0
Foliar fertilization – averaged	45.4							
Plant protection	544.0							
Afalon Flowable 450 SC	150.0							
Ridomil Gold MZ 68 WG	152.0							
Gwarant 500 SC	94.0							
Apacz 50 WG	48.0							
Calypso 480 SC	100.0							
Indirect sur plus	5511.7	5756.6	8160.0	7599.1	9510.7	9409.6	7923.1	7524.8
Indirect costs in total	2888.1							
Workforce of tractors and machines	2229.6							
Labour input	271.0							
Agricultural tax	125.0							
Other indirect costs (+10%)	262.6							
Total costs per 1 ha	6341.1	6802.1	6557.1	7018.1	6881.1	7342.1	6323.1	7054.1
Agricultural income, PLN·ha^{-1}	2623.6	2868.5	5271.9	4711.0	6622.5	6521.4	5035.0	4636.7
Direct surplus rate, %	61.5	59.5	69.0	64.8	70.4	67.9	69.8	64.4
Agricultural income rate, %	29.3	29.7	44.6	40.2	49.0	47.0	44.3	39.7
Unit costs, PLN·Mg^{-1}	200.8	197.9	163.1	176.2	162.0	168.1	166.0	179.5
Profitability index	1.4	1.4	1.8	1.7	2.0	1.9	1.8	1.7

source: the authors, based on the experiment results

In the future, better economic results of growing potatoes will have to be achieved through considerable intensification of cultivation treatments, which will allow Polish farmers to produce yields comparable to those harvested in other countries. However, it will be extremely difficult to compete with Israel, for example, where droplet irrigation of potato fields and fertilization with up to 350 N kg·ha^{-1} are practiced [Moritz 2015]. Besides, in many countries, potatoes are grown on very large fields, which helps reduce costs. Noteworthy, about 50% of potatoes grown in Israel are exported and the main selling market is Europe [Moritz 2015].

Table 5. Specification of profitability index values for the tested production technologies applied to the selected starch potato cultivars

Soil fertilization variant	Foliar fertillization variants								
	a	b	c	d	e	f	g	h	mean
Adam									
A	1.43	1.42	1.39	1.42	1.40	1.43	1.40	1.42	1.41
B	1.50	1.50	1.55	1.56	1.50	1.53	1.55	1.52	1.53
Mean	1.46	1.46	1.47	1.49	1.45	1.48	1.47	1.47	1.47
Pasja Pomorska									
A	1.92	1.86	1.87	1.87	1.85	1.85	1.87	1.83	1.87
B	1.85	1.82	1.85	1.88	1.84	1.83	1.86	1.87	1.85
Mean	1.89	1.84	1.86	1.87	1.84	1.84	1.86	1.85	1.86
Ślęza									
A	2.16	2.03	2.18	2.12	2.21	2.15	2.10	2.09	2.13
B	2.13	2.17	2.13	2.21	2.18	2.24	2.20	2.23	2.19
Mean	2.15	2.10	2.16	2.17	2.20	2.20	2.15	2.16	2.16
Mean for cultivars									
A	1.83	1.76	1.80	1.79	1.81	1.80	1.78	1.77	1.79
B	1.82	1.82	1.83	1.87	1.83	1.86	1.86	1.86	1.84
Mean	1.82	1.79	1.82	1.83	1.82	1.83	1.82	1.82	1.82

source: the authors, based on the experiment results

Table 6. Economic efficiency of the tested production technologies applied to the selected starch potato cultivars

Specification Wyszczegolnienie PLN·ha^{-1}	Soil fertilization variants	Foliar fertillization variants*							
		a	b	c	d	e	f	g	h
Adam									
Tuber yield value	A	8104	8043	7808	8023	7924	8101	7901	8023
Tuber yield value increase**		20.3	81.0	-215.1	-215.1	0	-98.7	78.4	–
Tuber yield value	B	8511	8506	8822	8921	8526.1	8741	8855	8686
Tuber yield value increase**		-174.6	-179.7	136.6	235.3	-159.4	55.7	169.6	–
Pasja Pomorska									
Tuber yield value	A	11197	10811	10911	10895	10743	10746	10862	10660
Tuber yield value increase**		537.3	151.2	251.1	234.9	83.7	86.4	202.5	–
Tuber yield value	B	10770	10571	10746	10919	10703	10614	10824	10892
Tuber yield value increase**		-121.5	-321.3	-145.8	27	-189	-278.1	-67.5	–
Ślęza									
Tuber yield value	A	12738	11892	12856	12464	13024	12676	12316	12266
Tuber yield value increase**		472	-374.7	590	197.7	758.2	410.1	50.2	–
Tuber yield value	B	12505	12803	12555	13060	12844	13225	12962	13163
Tuber yield value increase**		-657.9	-359.9	-607.7	-103.3	-318.6	61.9	-200.6	–

* description in Material and Methods; ** relative to technology h
source: the authors, based on the experiment results

CONCLUSIONS

1. Of the three tested potato cultivars, medium-late cultivar with an average starch content – Pasja Pomorska responded the best to foliar fertilization. Both the yields and yield increments relative to the control were the highest at soil fertilization of 280 kg·ha^{-1} NPK (80 N, 80 P, 120 K) and foliar application Basfoliar 12-4-6 in a dose of 8 dm^3·ha^{-1}.

2. Considering the ratio of the yields to costs, Ślęza (late cultivar with a high starch content) - was characterized by the best profitability index, which in every technological variant reached a value of over 2.0. From the point of view of rational economy, the most profitable was the fertilization combination which consisted of soil fertilization with 420 kg·ha^{-1} NPK (120 N, 144 P, 156 K) and foliar application of Basfoliar 12-4-6 with Solubor DF in amounts of 4 + 1 dm^3·ha^{-1}.

3. In terms of production profitability, the medium-early cultivar with an average starch content – Adam (a performed the worst). The profitability index values scored by this cultivar were the lowest.

4. Costs of tractors and machines make up a large share of the total costs of potato production technologies, which is why the best solution is to use the effect of production scale, which will enable farmers to reduce overall costs by using more efficient machines. Another possibility is to use the outsourcing of the most expensive cultivation treatments.

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OCENA EKONOMICZNA RÓŻNYCH SPOSOBÓW NAWOŻENIA ZIEMNIAKA DO PRZETWÓRSTWA PRZEMYSŁOWEGO

Streszczenie. W pracy zaprezentowano obliczenia będące wynikami doświadczenia polowego związanego z wpływem zróżnicowanego nawożenia wybranych odmian ziemniaka do przetwórstwa przemysłowego. Zamieszczone zestawienia dotyczą badań nad odmianami: Adam, Pasja Pomorska i Ślęza, wykonanych w latach 2008-2010, prowadzonych w Stacji Doświadczalnej Uniwersytetu Warmińsko-Mazurskiego w Bałcynach. Analizy ekonomicznej dokonano na podstawie zaplanowanych i zrealizowanych zabiegów oraz danych dotyczących rodzaju sprzętu technicznego, nakładów siły roboczej i pociągowej oraz nakładów materiałowych. Na podstawie eksperymentu stwierdzono, że badane odmiany ziemniaka skrobiowego bardzo różnie reagowały na nawożenie dolistne. Najlepiej plonowała odmiana Pasja Pomorska przy nawożeniu doglebowym 280 $kg \cdot ha^{-1}$ NPK (80 N, 80 P, 120 K) i dolistnym stosowaniu Basfoliaru 12-4-6 w ilości 8 $dm^3 \cdot ha^{-1}$. Biorąc pod uwagę relacje uzyskanych wyników do poniesionych kosztów, odmiana Ślęza charakteryzowała się najlepszym wskaźnikiem opłacalności, który przy każdym wariancie osiągał wartość ponad 2.0. Najkorzystniejszą z punktu widzenia racjonalności gospodarowania była kombinacja nawożenia na poziomie 420 $kg \cdot ha^{-1}$ NPK (120 N, 144 P, 156 K) oraz z zastosowaniem Basfoliaru 12-4-6 z Soluborem DF w ilości 4 + 1 $dm^3 \cdot ha^{-1}$. Uzyskano w tym przypadku najwyższy poziom wskaźnika opłacalności.

Słowa kluczowe: koszty produkcji, nawożenie dolistne, ochrona przed chorobami, opłacalność produkcji, wartość produkcji, ziemniak skrobiowy

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