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ANALYSIS OF THE ELEMENTS OF EDIBLE POTATO CULTIVATION TECHNOLOGIES IN SMALL ENVIRONMENT-FRIENDLY FARMS

Summary

The present study covers an analysis of edible potato production technologies that are used in agricultural practice in small environment-friendly farms. The research focuses on the influence of machinery on energy inputs, costs and labour intensity. It was found that the selection and use of machinery results in a distinct variation of the edible potato production efficiency in small environment-friendly farms. The power of those farm tractors that are in use is frequently in excess of the requirements of the farm. The operating efficiency of agricultural machinery does not match in an adequate manner the power of used farm tractors. Research is required into an optimization of edible potato cultivation technologies that are used in practice in environment-friendly systems.
Key words*: potato production, potato cultivation, small farms, agricultural machines, farm tractors, energy, analysis*

1. Introduction

Potatoes are of a great significance in an environment-friendly plant production. Nevertheless, they are among the most difficult species that are grown in environment-friendly farms [6]. The reason is a high risk of diseases and pests with no possibility of a chemical protection of plantations. This involves the need of the use of numerous energy- and cost-consuming treatments with the use of machinery, and labour intensity increases, as well. In spite of this, potato cultivation in these farms is justified by the variety of the uses of the crop, a favourable function of the potato as a root plant in the crop rotation and the possibility to sell bulbs from early crops as a vegetable with a high market demand [2].

Due to high inputs with uncertain yields, edible potato cultivations constitute ca. 0.5 per cent in the structure of environment-friendly agricultural produce in Poland [3]. According to Szeptycki and Wójcicki [5], it is among others the mechanization level and the technology used that have an influence on the input efficiency in agriculture. Shepherd et al. [4] suggest that considering the changeability of natural and organizational conditions, research into production technologies is to be related to a given region.

The purpose of the present study was an analysis of the production technologies that are used in agricultural practice in relation to the edible potato grown in small environment-friendly farms. The studies focus on the influence on the machinery used on energy inputs, costs and labour intensity.

2. Methods

The studies concerning the edible potato cultivation in environment-friendly farms were conducted in the years 2010 – 2012. Six farms were selected for the purpose of the research that were located in the area of Zachodniopomorskie Province. Those farms were selected that possessed similar natural and soil conditions (soils of IVb and V classes), with the arable land areas being not greater than 10 hectares, and potato cultivations being not greater than 1 hectare. In the technologies analyzed, winter rye that was cultivated to obtain grain, an original in seed certification, was the forecrop for the edible potato of early varieties (Korona, Bila and Denar). The edible potato was fertilized with manure in the average dose of 35t·ha^{-1}. In the years covered by the research, the average yield of the potato was 20 t·ha^{-1}.

The studies were carried out directly in the farms based on the methodologies developed by IBMER [1, 7]. The energy inputs and the costs do not include the value of the materials used as they were close to one another. Transport was not taken into account, either.

3. Results

The average area of arable lands in the farms where the research was conducted was 8.4 hectares. The smallest farm possessed 6.2 hectares of arable lands, while the largest one had 9.9 hectares. The average area of the edible potato cultivation was 0.56 hectares and it was in the range from 0.43 to 0.65 hectares. The edible potato was cultivated after winter rye that was harvested to obtain grain. Once the grain was harvested, post-harvest cultivations were introduced. These involved an average energy input of 1,601 MJ·ha^{-1}. The average cost of this treatment was assessed to be 308 PLN·ha^{-1} with labour inputs of 4.3 man-hours·ha^{-1} (cf. Table 1). Coarse mulch disc tillers and a harrow were used in Farm no. 1, a cultivator in Farm no. 2, and a rotary cultivator in Farm no. 3. In the remaining farms, ploughs were used. The greatest energy input and the higher costs were in Farm no. 5, where a three-furrow plough with the power demand of 24kW combined with a 71kW tractor was used for the purpose of post-harvest cultivation. This operation required the least amount of energy and the lowest costs when performed with coarse mulch disc tillers (Farm no. 1).

In the technologies under analysis, the edible potato was fertilized with bovine manure in the average dose of 35t·ha^{-1}. In view of the fact that the manure doses were similar in all of the technologies, the inputs of energy and labour and costs of the operation depended from the machinery used. The largest energy inputs (close to 5,600 MJ·ha^{-1}) and the highest costs (more than 1,200 PLN·ha^{-1}) were borne, similarly as in the case of post-harvest cultivations, in Farm no. 5, where a 71 kW farm tractor was coupled with a manure spreader with a far smaller power demand (50 kW). The

smallest energy and labour inputs as well as the lowest costs were connected with a manure spreader in Farm no. 4, where the manure spreader used had a high operating efficiency and was well matched with the power of the farm tractor that it was used with (cf. Table 2).

Once manure had been taken to the field and spread, it was mixed with soil in a fall plough. It was also this operation that was the most energy and cost demanding in Farm no. 5, where a 71 kW farm tractor was coupled with a plough with the power demand of 28 kW. In Farm no. 4, for a fall plough, a farm tractor with a relatively large power of 75.5 kW was used, yet a five-furrow plough with a power demand of 74 kW was used. This involved such energy inputs and costs which did not deviate from the average values, and it distinctly lowered the labour intensity. Tillage with the use of a four-furrow plough coupled with a 48.5 kW farm tractor proved to be the least energy and cost demanding (cf. Table 3).

In spring cultivations, tillage and harrowing were most frequently used (Farms nos. 4-6). As evidenced by the data in Table 4, this operation, however, depending on the machinery used, was characterized by various inputs of energy and labour as well as diversified costs. In Farm no. 5, as in the case of the previously mentioned operations, for the purpose of tillage, a 71 kW farm tractor with a plough with a 24 kW power demand was used. Performing this operation twice with a cultivator proved to be the least energy and cost demanding (Farm no. 4).

Energy inputs in connection with potato planting ranged from nearly 1,700 to over 2,200 MJ·ha^{-1} (cf. Table 5). With the exception of Farm no. 5, where a four-row planter was used, this operation was performed with the aid of two-row planters, which increased labour inputs by 2.3 man-hours·ha^{-1}. If planters were used with the same operating efficiency, it was the tractor they were coupled with that was decisive of the energy inputs and costs. The greater its power was the higher the energy inputs and costs were.

Table. 1. Inputs of energy and labour as well as costs in relation to post-harvest cultivations connected with the edible potato cultivation in environment-friendly farms

Number of farms	Post-harvest cultivations				
	Tractor	Machine	Inputs of energy [MJ·ha^{-1}]	Human labour [man-hours·ha^{-1}]	Costs [zł·ha^{-1}]
	Typ/power [kW]	Typ			
1	U4512/48,5	U865/10	1090	2,8	203
	U4512/48,5	U423			
2	Z5211/34,2	U473/2 x 2	1153	4,0	234
3	C330/22,4	U533/2	1458	2,5	313
	C330/22,4	U212/2 x 2			
4	C360/38,2	U144/3	1707	5,1	316
	C360/38,2	B23 x 2			
5	U1012/71	U144/1	2476	4,7	425
	U1012/71	U217/2			
6	C360-3P/34,6	U144	1721	6,4	354
	C360-3P/34,6	U211/2			
Average			1601	4,3	308

Source: Author's calculations

Table. 2. Inputs of energy and labour as well as costs in relation to the fertilization of the edible potato cultivation in environment-friendly farms

Number of farms	Fertilization				
	Tractor	Machine	Inputs of energy [MJ·ha^{-1}]	Human labour [man-hours·ha^{-1}]	Costs [zł·ha^{-1}]
	Typ/power [kW]	Typ			
1	U4512/48,5	N227	5074	10,0	1044
2	Z5211/34,2	N243	4907	11,1	978
3	U914/57	N240	4741	8,3	1010
4	C360/38,2	N218/2	3830	7,1	924
5	U1012/71	RT 1/4	5592	8,3	1214
6	C330/22,4	N226	4616	14,8	959
Average			4793	9,9	1021

Source: Author's calculations

Table. 3. Inputs of energy and labour as well as costs in relation to fall cultivations connected with the edible potato cultivation in environment-friendly farms

Number of farms	Cultivations				
	Tractor	Plough	Inputs of energy [MJ·ha^{-1}]	Human labour [man-hours·ha^{-1}]	Costs [zł·ha^{-1}]
	Typ/power [kW]	Typ			
1	U4512/48,5	U036/2	990	2,5	211
2	Z5211/34,2	U023/1	1122	3,8	231
3	C330/22,4	U122	1133	5,6	237
4	Z1045/75,5	U183/1	1165	2,0	224
5	U1012/71	U160/3	1780	3,3	248
6	U4512/48,5	U036/2	990	2,5	211
Average			1197	3,3	227

Source: Author's calculations

Table. 4. Inputs of energy and labour as well as costs in relation to spring cultivations connected with the edible potato cultivation in environment-friendly farms

Number of farms	Spring cultivations				
	Tractor	Machine	Inputs of energy [MJ·ha^{-1}]	Human labour [man-hours·ha^{-1}]	Costs [zł·ha^{-1}]
	Typ/power [kW]	Typ			
1	U4512/48,5	U474/1 x2	1500	3,9	269
2	Z5211/34,2	U473/2	855	3,4	176
	C330/22,4	U211/2			
3	C330/22,4	U122	1272	6,3	272
	C330/22,4	U706			
4	Z1045/75,5	U651 x2	630	1,0	128
5	U1012/71	U037/2	1989	3,7	354
	U1012/71	U217/2			
6	C360-3P/34,6	U444/3	936	3,4	190
	C360-3P/34,6	U211/2			
Average			1197	3,6	232

Source: Author's calculations

Table. 5. Inputs of energy and labour as well as costs in relation to planting of the edible potato in environment-friendly farms

Number of farms	Planting				
	Tractor	Machine	Inputs of energy [MJ·ha^{-1}]	Human labour [man-hours·ha^{-1}]	Costs [zł·ha^{-1}]
	Typ/power [kW]	Typ			
1	C330/ 34,6	S222	1821	5,6	522
2	Z5211/34,2	S239	1713	5,6	516
3	C330/22,4	S211	1390	5,6	436
4	C360/38,2	S211	2114	5,6	541
5	U1012/71	S223	2203	3,3	512
6	C360-3P/34,6	S208/1	1684	5,6	516
Average			1821	5,2	507

Source: Author's calculations

Due to the fact that chemical protection of the potato plantation was not possible, weeds were mechanically controlled. In five farms, weeds were also removed manually (Table 6). Cultivation based solely on machinery (Farm no. 5) proved to be the most energy and cost consuming. This, however, involved the least human labour input. The least energy and cost consuming cultivation technique proved to be the two-time use of a ridging hoe and a manual removal of weeds (Farm no. 2).

The edible potato harvest was the most labour and cost consuming process in the technologies analyzed. High labour inputs were the result of the potato being harvested by stages, depending on the market demand. Potatoes were dug by means of potato diggers, usually with two-row diggers (single-row diggers were used in Farms nos. 2 and 3), and they were further manually sorted and packed (Table 7).

Table. 6. Inputs of energy and labour as well as costs in relation to the growing of the edible potato in environment-friendly farms

Number of farms	Growing				
	Tractor	Machine	Inputs of energy [MJ·ha^{-1}]	Human labour [man-hours·ha^{-1}]	Costs [zł·ha^{-1}]
	Typ/power [kW]	Typ			
1	C330/ 34,6	P475/1 x 2	800	12,9	247
		Hand weeding			
2	C330/22,4	P463/1 x2	766	10,0	215
		Hand weeding			
3	C330/22,4	P468 x2	1019	13,2	302
	C330/22,4	Chwastownik			
		Hand weeding			
4	C360/38,2	P468/1 x2	1108	12,3	298
	C360/38,2	KLIMZA			
		Hand weeding			
5	U1012/71	P475/1 x2	2204	4,1	361
	U1012/71	P510			
6	C330/ 34,6	PIEL5	988	13,7	289
	C330/ 34,6	P446 x2			
		Hand weeding			
Average			1148	11,0	285

Source: Author's calculations

Table. 7. Inputs of energy and labour as well as costs in relation to the harvesting of the edible potato in environment-friendly farms

Number of farms	Harvesting				
	Tractor	Machine	Inputs of energy [MJ·ha^{-1}]	Human labour [man-hours·ha^{-1}]	Costs [zł·ha^{-1}]
	Typ/power [kW]	Typ			
1	C330/ 34,6	Z609/0-2	2150	116	1336
	Manual harvesting				
2	C330/22,4	Z631	2985	123	1537
	Manual harvesting				
3	C330/22,4	Z632	2545	123	1537
	Manual harvesting				
4	C360/38,2	Z640/3	2165	116	1427
	Manual harvesting				
5	U1012/71	Z609/3	3607	116	1521
	Manual harvesting				
6	C330/ 34,6	Z640/2	2432	117	1437
	Manual harvesting				
Average			2647	119	1466

Source: Author's calculations

The highest energy inputs were incurred in connection with potato harvesting in Farm no. 5, the reason being the use of a farm tractor with its power being too great in relation to the needs (18 kW). In those farms, where two-row diggers with suitably matched farm tractors were used, the inputs of energy and labour as well as costs were lower than those in the farms where single-row diggers were used.

The edible potato production technologies under analysis, in spite of the natural conditions of the farm being very similar, exhibited a clear diversification of the inputs of energy, human labour and costs (Table 8). The inputs of energy in relation to operations involving machinery and human labour in the edible potato production were 14,488 MJ·ha^{-1} on the average, and they were in the range from 12,719 to 19,851 MJ·ha^{-1}. These were labour-intensive technologies, which required from 142 to 167 man-hours·ha^{-1}. The lowest production cost was 3,831, and the highest was 4,635 PLN·ha^{-1}.

Table. 8. Inputs of energy and labour as well as costs in relation to the production of the edible potato cultivation in environment-friendly farms

Number of farms	Costs		
	Inputs of energy [MJ·ha^{-1}]	Human labour [man-hours·ha^{-1}]	Costs [zł·ha^{-1}]
1	13425	154	3831
2	13501	161	3887
3	13555	165	4107
4	12719	149	3858
5	19851	143	4635
6	13875	167	3956
Average	14488	156	4045

Source: Author's calculations

4. Conclusions

1. The selection and the use of machinery results in a distinct diversification of the efficiency of the edible potato production in small environment-friendly farms.
2. The power of the used farm tractors is frequently in excess of the needs of the farm.
3. The operating efficiency of agricultural machinery does not adequately match the power of the used farm tractors.
4. Research is required into an optimization of the technologies used in practice of the edible potato cultivation in an environment-friendly system.

5. References

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