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CULTIVAR-RELATED AND AGRONOMIC CONDITIONS OF RYE YIELDING ON GOOD RYE COMPLEX SOIL PART II. EFFECTIVENESS OF DIFFERENT CULTIVATION TECHNOLOGIES

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ABSTRACT

The present paper covers economic analysis (concerning energy and cost aspects) of rye production technologies employing different cultivars, sowing dates, NPK fertilisation, microelements nourishment and weed control. Intensive production of rye using a hybrid cultivar, early sowing and NPK fertilisation at 176 kg·ha^{-1} produced 46% higher yields compared to extensive technologies involving open pollination cultivars and low fertiliser rates. The highest energy consumption in winter rye production was caused by NPK fertilisation. Intensive technologies were less energy-effective than extensive methods. The direct costs of growing 1 ha of rye in extensive technologies equalled 2.2 – 2.9 t grain. In intensive technologies direct costs were returned at yields as high as 3.9 – 4.6 t per ha. The yield value increment resulting from more intensive production methods did not cover completely the increase in direct costs. Therefore, the surplus of production in intensive technologies was lower (by an average of 7-10%) than in extensive systems.

Key words: winter rye, technology of production, accumulated energy, energy effectiveness, direct costs, production surplus, production cost per unit

INTRODUCTION

The choice of a production technology in market economy should be preceded by economic calculations [10]. Production of cereals in Poland is low and the energy expenses per 1 ha grain production varies from 17 to 25 GJ depending on the intensity of production methods. The analysis of energy expenditure structure shows that the level of fertilisation and use of energy carriers are the dominant elements in the energy inputs of cereals production [3,5].

The profitability of rye production is low [7,12]. In the study completed by Gołębiewska and Klepacki [7], the lowest direct surplus was attained from 1 ha winter rye field (the cultivation techniques applied notwithstanding). Kowalczyk [12] showed that rye production unit cost in Poland was higher than in the countries of Western Europe and exceeded the unit cost of wheat or barley grain production [12]. Costs of traditional production methods (extensive) of winter rye are as high as 300 €·ha^{-1}, which equals 2.8 t grain [20]. With high input technologies (hybrid, 220 kg·ha^{-1} NPK, weed control, protection against diseases), the return of direct costs was possible at yields reaching 4.8 t grain. The current relation of production means costs to the price of grain makes high input technologies of rye production economically less efficient than traditional medium intensive methods [2]. Similar relationships were previously shown for other species of cereals [13,18,19].

The working hypothesis for this study was aimed to select (on the basis of a strict experiment presented in part I of the paper [4]) 3 most efficient and 3 least efficient cultivation technologies for winter rye production and to subject them to economic and energy consumption analysis. In this way, it would be possible to determine whether an increase in inputs (energy and financial outlays) raised the efficiency of winter rye grain production.

MATERIAL AND METHODS

The analysis of energy and cost efficiency of winter rye production was based on two sources of data:

- a strict field experiment to determine efficiency of different combinations of agronomic factors, their description can be found in the first part of the publication [4],
- direct measurement of technological processes on production fields, which allowed to determine the level of financial and energy expenses per 1 ha rye.

In the experiment set in a half replication 2^{5-1} design, a combination of five factors on two levels makes it possible to create 16 independent technologies (variants) of grain production. Some of these 16 variants were selected for economic comparisons using quartile as a statistical instrument.

The final economic analysis was carried out on 3 best and 3 worst combinations (referred to as variants of technologies) of agronomic factors, which produced high and low winter rye grain yields, respectively. The upper quartile (Q_3), which for an ordered variable determines increasingly the values of upper 25% observations, was taken as a criterion to determine the subset of large yields. By analogy, to establish a subset of small yields, the lower quartile (Q_1) was taken, which sets out the 25% observations of the lowest yields. In the subset of large yields the combinations with the frequency of occurrence of the analysed agronomic factors on the higher level '1', being the highest, were considered most favourable. The least favourable were these combinations in the subset of small yields in which the repeatability of agronomic factors on the higher level was smallest. Based on the analyses, 3 most effective and 3 least effective variants of winter rye production were selected and subjected to energy evaluation (energy efficiency factor, energy consumption per unit) and cost analysis (surplus of production, unit cost of producing 1 ton of rye grain).

The outlays of accumulated energy and direct costs were assessed using the method of process analysis according to own direct measurements of fuel consumption, labour expense and real efficiency of machines and tools on production fields at Bałcyny, with machines and tools typical for agricultural production: U1224 + U103/1 Atlas 4H (ploughing), U1224 + U774/2 (cultivating aggregator), U452 + U212/2 (harrowing), U4512 + N035 RNW-3 (pre-sowing PK fertilisation), U1224 + S052/C Mazur 5 (sowing of seeds), P211 Redło (seed dressing), U1224 + N039 RNZ-3 (N top-dressing), U4512 + Pilmet 612 (chemical protection), Bizon-Rekord (grain harvest), U4512 + D734 (grain transport).

The energy consumption analysis distinguished four streams of energy: human labour, energy carriers, materials (fertilisers, seeds, pesticides), machines and tools. The energy outlays caused by the use of machines and tools in the production process were computed by multiplying the unit material consumption of the machine set by the energy equivalent of 112 MJ·kg^{-1} weight [17]. Human labour was calculated by the equivalent of 40 MJ·work h^{-1} [1,8,17]. The volume of energy outlays spent on materials was calculated with the help of accumulated energy factors presented by Juszkiewicz et al. [8]. The gross energy value of rye grain was determined by adiabatic burning of grain in a calorimetric bomb at the Institute of Animal Nourishment and Feeds Management of the Olsztyn University of Warmia and Mazury. For the evaluation of energy the following categories were used: accumulated energy gain, unit energy consumption, energy consumption effectiveness (efficiency) factor, energy effectiveness (efficiency) factor [21,22].

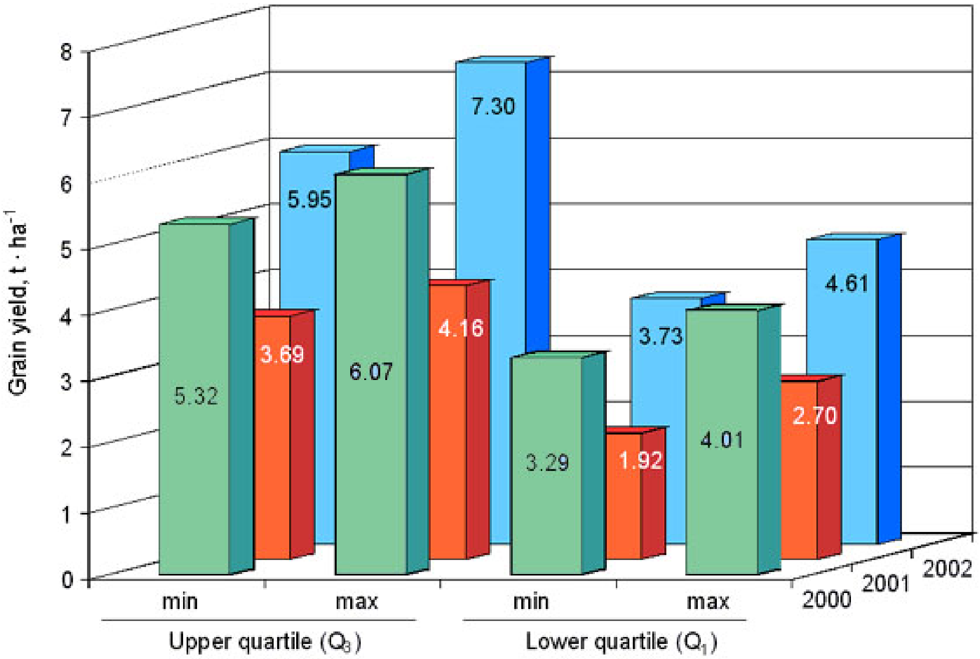
Unit maintenance costs (maintenance and use) of tractors and agricultural machines were calculated with the methods elaborated by the Institute for Building, Mechanisation and Electrification of Agriculture – IBMER [6]. Apart from the tractive force, human labour and costs of commercial means of production and energy carriers were included in the evaluation of the direct costs. The cost of human labour was calculated relative to the income of farmers, calculated at the level of 1.76 €·h^{-1} (i.e. 7.0 PLN·h^{-1}). Costs of industrial means of production (seeds, fertilisers, herbicides, and energy carriers) were estimated according to the market prices in the first six months of the year 2002. In the evaluation of the value of the output, the selling price of grain of 78.97 €·t^{-1} (314 PLN·t^{-1}) was used. When converting PLN to €, the rate of 1 € = 3.976 PLN was taken. For the economic analysis the factors presented by Mierzejewska [16] and Kisiel and Jankowski [9] were used related only to the direct production costs.

RESULTS AND DISCUSSION

Description of large and small yield groups

The analysed subset of 'large yields' contained yields ranging from 3.69 to 7.30 t·ha^{-1}, whereas the yields in the subset of 'small yields' reached 1.92 to 4.61 t·ha^{-1} (Fig. 1).

Fig. 1. Statistical specification of winter rye yields in the upper and lower quartiles



In the group of large yields, of all the analysed combinations (the data from three years), factor B – cultivar, repeated most frequently (24 times), followed by factor C – NPK rate (23 times) and factor A – date of sowing (21 times) (Table 1). The remaining factors (D, E) revealed less frequent recurrence (16 and 18 times). The data suggest that a combination involving a hybrid cultivar, optimum date of sowing and NPK fertilisation at the rate of 176 kg·ha^{-1} guaranteed high yields. Presence (level '1') or absence (level '0') of the other analysed agronomic factors was not a necessary condition for attaining high yields of winter rye. The study conducted by Kuś and Jończyk [14] showed that out of the seven agronomic factors tested, four determined high yields of rye: chemical eradication of diseases, use of anti-lodging agent, nitrogen fertilisation and early spring application of nitrogen.

Table 1. Frequency of occurrence of objects with higher factor level ‘1’ (number of treatments on factors level ‘1’)

Year	Upper quartile (Q_3)					Lower quartile (Q_1)				
	A	B	C	D	E	A	B	C	D	E
2000	8	6	6	4	4	2	2	0	5	3
2001	4	6	6	5	5	8	3	3	4	4
2002	9	12	11	7	9	3	0	1	5	3
Total	21	24	23	16	18	13	5	4	14	10

A, B, C, D, E – agronomic factors (for details, see Part I [4])

Low yields of winter rye (lower quartile) were mainly caused by the lowest repeatability of higher levels (‘1’) of factors B and C that is the hybrid cultivar and higher NPK fertilisation. Probability of obtaining low yields of winter rye was the highest when growing a population cultivar fertilised with a low rate (88 kg·ha^{-1}) of NPK. In the group of low yields different dates of sowing or application of microelements fertilisation and herbicide treatments did not have any considerable effect on the volume of the grain yields obtained.

Table 2 presents the three most productive and three least productive variants of winter rye production technology. High yielding variants typically involved the use of a hybrid cultivar, unlike the low yielding variants, in which a population cultivar was cultivated. The difference between the combinations of most productive factors (high yields group) and least productive factors (low yields group) was as high as ± 0.97 t·ha^{-1} relative to the mean arithmetic yield attained in the experiment.

Table 2. Yields of 3 best and 3 worst combinations of agronomic factors (mean from three years)

Yield group	Combination of factors					Mean yield for technology t·ha^{-1}	Mean effect in grain yield t·ha^{-1}
	A	B	C	D	E		
High	1	1	1	0	1	5.35	+0.97
	1	1	1	1	0	5.16	+0.78
	1	1	0	1	1	5.04	+0.66
Low	1	0	0	1	0	3.67	-0.71
	0	0	0	1	1	3.53	-0.85
	0	0	0	0	0	3.41	-0.97

A, B, C, D, E – agronomic factors; “0”, “1” – levels of agronomic factor (for details, see Part I [4])

Energy and economic efficiency of some rye production technologies

Low and high yield variants of cultivation, distinguished on the basis of subsets (quartiles), were subject to energy and economic analysis (Table 3-8).

The level of energy outlays on high yield variants of winter rye cultivation varied from 11.1 GJ·ha^{-1} to 15.4 GJ·ha^{-1} (Table 3). The accumulated energy outlays to grow 1 ha winter rye were 10-31% lower in the low yield group. Differences within the groups and between the variants of production can be mainly attributed to the levels of NPK fertilisation (88 or 176 kg·ha^{-1}). NPK fertilisation with the rates of 88 kg·ha^{-1} consumed 39-44% of the total accumulated energy outlays used to grow 1 ha winter rye. Elevating the fertiliser rate to the naturally optimal level (176 kg·ha^{-1}) made the share of this energy outlay structure component exceed 55%. As regards the other agronomic treatments, sowing and seed material (2.9 - 3.2 GJ·ha^{-1}) followed by pre-sowing soil cultivation (1.8 GJ·ha^{-1}) played an important role in the level of energy consumption of winter rye production, irrespective of the technology variants. Large energy consumption connected with fertilisation and a strong relationship between fertiliser rates and total energy input in grain production were also indicated by the results of Korona et al. [11], Budzyński and Szempliński [5] and Budzyński et al. [2].

Table 3. Accumulated energy outlays to grow 1 ha rye (MJ) according to production activities

Production activity	Technology variant						
	High production variant				Low production variant		
		I	II	III	IV	V	VI
	A	1	1	1	1	0	0
	B	1	1	1	0	0	0
	C	1	1	0	0	0	0
	D	0	1	1	1	1	0
	E	1	0	1	0	1	0
Tillage		1 789	1 789	1 789	1 789	1 789	1 789
Sowing and seed material		3 170	3 170	3 170	2 892	2 892	2 892
Fertilization, including:		8 578	8 662	4 365	4 365	4 365	4 282
– macroelements (NPK)		8 578	8 579	4 282	4 282	4 282	4 282
– microelements		0	83	83	83	83	0
Weed control		520	0	520	0	520	0
Harvesting		1 323	1 222	1 222	974	974	974
Total		15 380	14 843	11 066	10 020	10 540	9 937

A, B, C, D, E – agronomic factors; ‘0’, ‘1’ – levels of agronomic factor (for details, see Part I [4])

Materials dominate the structure of accumulated energy consumption viewed as streams of energy flow (64-71% of the total inputs) (Table 4). Large material consumption in rye grain production is due to a large energy outlay to purchase fertilisers and seed material. Next to the materials, an important position in the structure of inputs is occupied by energy carriers (24-29%). In the authors own research, the highest energy efficiency was achieved by variant III, which involved the lower level of NPK fertilisation (level ‘0’; 88 $kg \cdot ha^{-1}$) and higher levels (‘1’) of the other agronomic factors (Table 5). In this variant 1 MJ spent on growing rye produced a yield increase of 7.5 MJ. Higher levels of microelements fertilisation without weed control (variant II) or foliar microelements fertilisation (variant I) depressed the index of energetic efficiency by 24%, increasing unit energy consumption of grain production by 31%. High input technologies (high yield technologies) were more energy-efficient (by an average 10%) than extensive methods.

Table 4. Accumulated energy outlays to grow 1 ha rye (MJ) according to energy streams

Stream of energy	Technology variant						
	High production variant				Low production variant		
		I	II	III	IV	V	VI
	A	1	1	1	1	0	0
	B	1	1	1	0	0	0
	C	1	1	0	0	0	0
	D	0	1	1	1	1	0
	E	1	0	1	0	1	0
Labour force		289	275	271	235	255	225
Tractors and machinery		567	534	522	442	456	434
Energy carriers		3 619	3 486	3 245	2 931	3 057	2 869
Materials, including:		10 905	10 548	7 028	6 412	6 772	6 409
– seeds		2 690	2 690	2 690	2 442	2 442	2 442
– fertilizers		7 760	7 763	3 883	3 883	3 883	3 880
– fungicides		95	95	95	87	87	87
– herbicides		360	0	360	0	360	0

A, B, C, D, E – agronomic factors; ‘0’, ‘1’ – levels of agronomic factor ((for details, see Part I [4])

Table 5. Energy evaluation parameters of some winter rye cultivation technologies

Specification		Technology variant					
		High production variant			Low production variant		
		I	II	III	IV	V	VI
	A	1	1	1	1	0	0
	B	1	1	1	0	0	0
	C	1	1	0	0	0	0
	D	0	1	1	1	1	0
	E	1	0	1	0	1	0
Energy value of yield, MJ·ha^{-1}		88 275	85 140	83 160	60 555	58 245	56 265
Total energy input, MJ·ha^{-1}		15 380	14 843	11 066	10 020	10 540	9 937
Energy surplus, MJ·ha^{-1}		72 895	70 297	72 094	50 535	47 705	46 328
Energy consumption per unit, MJ·t^{-1}		2 875	2 767	2 196	2 730	2 986	2 914
Index of energetic efficiency		5.74	5.74	7.51	6.04	5.23	5.66

A, B, C, D, E – agronomic factors; ‘0’, ‘1’ – levels of agronomic factor (for details, see Part I [4])

The direct costs of rye cultivation varied from 173-225 €·ha^{-1} (low input variants) to 311-360 €·ha^{-1} (high input variants) (Table 6). In the hybrid cultivation (variants I-III) sowing (33-38% of the total direct costs) and macroelements fertilisation (17-33%) turned out to be most expensive. In the low input technologies (variants IV-VI) NPK fertilisation (24-30%) and soil cultivation incurred the highest costs.

The material outlays played a dominant role in shaping the direct costs of growing winter rye, reaching 61-64% of the total direct costs of rye cultivation (Table 7). When growing the hybrid cultivar (variants I-III) the purchase of the seed material constituted nearly 1/3 of the direct costs (102.5 €·ha^{-1}). The cost of buying the seed material was 25% higher than the cost of purchasing the fertilisers (both macro- and microelements). The seed material of the population cultivar (variants IV-VI) was four-fold less expensive than that of the hybrid.

Table 6. Direct costs of growing 1 ha rye (€) according to production activities

Production activity		Technology variant					
		High production variant			Low production variant		
		I	II	III	IV	V	VI
	A	1	1	1	1	0	0
	B	1	1	1	0	0	0
	C	1	1	0	0	0	0
	D	0	1	1	1	1	0
	E	1	0	1	0	1	0
Tillage		46.6	46.6	46.6	46.6	46.6	46.6
Sowing and seeds		118.9	118.9	118.9	42.1	42.1	42.1
Fertilisation, including:		99.6	103.8	53.3	53.3	53.3	49.1
– macroelements (NPK)		99.6	99.6	49.1	49.1	49.1	49.1
– microelements		0	4.2	4.2	4.2	4.2	0
Weed control		48.2	0	48.2	0	48.2	0
Harvesting		47.1	43.6	43.6	35.1	35.1	35.1
Total		360.4	312.9	310.6	177.1	225.3	172.9

A, B, C, D, E – agronomic factors; ‘0’, ‘1’ – levels of agronomic factor (for details, see Part I [4])

Table 7. Direct costs of growing 1 ha rye (€) according to sources of costs

Source of costs	Technology variant						
	High production variant				Low production variant		
		I	II	III	IV	V	VI
	A	1	1	1	1	0	0
	B	1	1	1	0	0	0
	C	1	1	0	0	0	0
	D	0	1	1	1	1	0
	E	1	0	1	0	1	0
Labour		12.7	12.1	11.9	10.3	11.2	9.9
Tractors and machinery		71.2	67.3	66.5	57.4	60.4	55.9
Energy carriers		46.0	44.3	41.3	37.3	38.9	36.5
Materials, including:		230.5	189.2	190.9	72.1	114.8	70.6
– seeds		102.5	102.5	102.5	26.8	26.8	26.8
– fertilisers		80.7	82.2	41.1	41.1	41.1	39.7
– fungicides		4.6	4.6	4.6	4.2	4.2	4.2
– herbicides		42.8	0.0	42.8	0.0	42.8	0.0

A, B, C, D, E – agronomic factors; ‘0’, ‘1’ – levels of agronomic factor (for details, see Part I [4])

The return of the direct costs of growing 1 ha of winter rye in low yield technologies (IV-VI) was possible at the unit yield reaching 2.2-2.9 t·ha^{-1} (Table 8). The costs of high input technologies (variants I-III) were returned when the yields reached 3.9-4.6 t·ha^{-1}. Interestingly, the direct surplus of growing winter rye was higher (by 46%) when using extensive technologies. Exceptionally high profitability was achieved by sowing the population cultivar on the optimal date of sowing (non-input bearing factor), using the NPK rate of 88 kg·ha^{-1} and microelements fertilisation, but doing without chemical weed control (variant IV), as well as in variant VI, where all the agronomic factors were on level ‘0’. In these technologies the costs of producing 1 ton of grain were by an average 22% lower than in high input technologies. The highest unit cost of producing grain (67.4 €·ha^{-1}) appeared in the variant involving the hybrid ‘Esprit’ fertilised with the optimal NPK rate (176 kg·ha^{-1}) and chemically weeded (variant I), even though this was the most productive variant.

Table 8. Components of the economic analysis of some winter rye cultivation technologies

Specification	Technology variant						
	High production variant				Low production variant		
		I	II	III	IV	V	VI
	A	1	1	1	1	0	0
	B	1	1	1	0	0	0
	C	1	1	0	0	0	0
	D	0	1	1	1	1	0
	E	1	0	1	0	1	0
Yield value, €·ha^{-1}		422.5	407.5	398.0	289.8	278.8	269.3
Direct costs of cultivation, €·ha^{-1}		360.4	312.9	310.6	177.1	225.3	172.9
Yield covering direct costs of cultivation, t·ha^{-1}		4.56	3.96	3.93	2.24	2.85	2.19
Production surplus, €·ha^{-1}		62.1	94.6	87.4	112.7	53.5	96.4
Cost of producing 1 t grain, €		67.4	60.6	61.6	48.3	63.9	50.8

A, B, C, D, E – agronomic factors; ‘0’, ‘1’ – levels of agronomic factor (for details, see Part I [4])

The data shown in Tables 6, 7 and 8 prove that on soil of good rye complex (poor soil) high input technologies made it possible to obtain higher (by an average 32%) grain yields than low input technologies. However, the increment of the financial value of higher yields caused by more intensive systems of production (by about 130 €·ha^{-1}) did not offset the increase in the costs, which meant that the surplus of production diminished and the cost of producing 1 ton of grain increased. Likewise, Maciorowski et al. [15] claim that making production more intensive by selecting a hybrid cultivar increases the unit cost of production. The authors believe that improved efficiency compared to traditional technologies (with a population cultivar) can be achieved only when the hybrid produces yields of 7 t·ha^{-1}. The results reported by Budzyński [2] also suggest that making rye cultivation more intensive by using hybrid cultivars, higher fertilisation rates and complete chemical plant protection resulted in depressing the grain production profitability by 24%.

CONCLUSIONS

1. On poor soil of good rye complex, a high input rye cultivation technology with a hybrid cultivar, early sowing date and fertilisation at a rate of 176 kg·ha^{-1} NPK made it possible to obtain yields 46% higher than those produced by low input technologies using a population cultivar and low fertiliser rates.
2. The most energy consuming chain of winter rye agronomic cultivation practices was constituted by NPK fertilisation. Therefore, high input technologies (with high NPK fertilisation rates) were characterised by lower (by an average of 6-7%) energy efficiency than low input systems.
3. The direct costs of growing 1 ha rye in extensive technologies, expressed as a volume of grain, were equal 2.2-2.9 t grain. In the intensive technologies the direct costs return did not occur until the yields reached 3.9-4.6 t per ha.
4. The yield value increment (by 46%) caused by using high input technologies did not cover completely the direct costs increase. Consequently, the production surplus in high input technologies (hybrid, high NPK fertilisation) was lower (by an average 7-10%) than in low input technologies (population cultivar, low NPK fertilisation). The lowest cost of producing 1 t grain of rye was obtained in the technology using the population cultivar, low NPK fertilisation without chemical weed control. The other agronomic factors did not have any significant effect on the unit cost of production.

REFERENCES

1. Anuszewski R., 1987. Metoda oceny energochłonności produktów rolniczych (MET) [Method of evaluating agricultural products energy-consumption (MET)]. Zagad. Ekon. Roln. 4, 16-26 [in Polish].
2. Budzyński W., 2001. Czynniki ograniczające plonowanie żyta [Factors limiting rye yielding]. Pam. Puł. 128, 25-37 [in Polish].
3. Budzyński W., Dubis B., Wróbel E., 2000. Ekonomiczna i energetyczna efektywność różnych sposobów pielęgnacji i nawożenia pszenżyta ozimego [Economic- and energy-effectiveness of various methods of winter triticale cultivation and fertilisation methods]. Folia Univ. Agric. Stetin., Agricultura 82, 31-38 [in Polish].
4. Budzyński W., Jankowski K., Szempliński W., 2003. Cultivar related and agronomic conditions of the yielding of rye on good rye complex soil. Part I. Yield and its relationship with the yield structure components. Elec. J. Polish Agric. Univ., Agronomy 6 (1), www.ejpau.media.pl.
5. Budzyński W., Szempliński W., 1996. Rolnicza, jakościowa i energetyczna ocena różnych sposobów odchwaszczania i nawożenia azotem jarej pszenicy chlebowej. Cz. II. Energochłonność uprawy [Agricultural, quality and energetic evaluation of various spring bread wheat weed control and nitrogen fertilisation methods. Part II. Energy-consumption of cultivation]. Rocz. Nauk Roln. 112 A (1-2), 93-101 [in Polish].
6. Goć E., Muzalewski A., 1997. Koszty eksploatacji maszyn [Machinery exploitation costs]. IBMER Warszawa [in Polish].
7. Gołębiewska B., Klepacki B., 2002. Zastosowanie rachunku ekonomicznego w podejmowaniu decyzji w zakresie wyboru technologii produkcji zbóż [Application of economic calculation to cereals production technology selection decision-making]. W: Produkcja i rynek zbóż. Red. J. Rozbicki. Wyd. Wieś Jutra, 305-316 [in Polish].
8. Juszkiewicz M., Kaliszewicz D., Kucka E., 1994. Energochłonność uprawy kukurydzy oraz różnych sposobów jej konserwacji [Energy-consumption of corn cultivation and its various preservation methods]. Acta Acad. Agric. Tech. Olst., Oeconomica 30, 79-86 [in Polish].
9. Kisiel R., Jankowski K., 1999. Economic efficiency of nitrogen fertilization and pest control of winter rape. Natur. Sci. 2, 5-15.
10. Kisiel R., Kaliszewicz D., 1996. Kalkulacje kosztów jednostkowych wybranych produktów roślinnych [Calculations of selected plant products unit costs]. RARR Olsztyn [in Polish].
11. Korona E., Budzyński W., Fedejko B., 1994. Rolnicza i energetyczna ocena różnych sposobów nawożenia azotem pszenżyta jarego [Agricultural and energetic evaluation of various spring triticale nitrogen fertilisation methods]. Zesz. Nauk. AR Szczecin, Rolnictwo 162, 82-84 [in Polish].
12. Kowalczyk S., 2002. Opłacalność produkcji zbóż w Polsce i Unii Europejskiej [Profitability of cereals production in Poland and in the European Union]. W: Produkcja i rynek zbóż. Red. J. Rozbicki. Wyd. Wieś Jutra, 317-325 [in Polish].
13. Krasowicz S., 1997. Kalkulacje dotyczące uprawy zbóż [Cereals cultivation calculations]. Mat. Szkol. IUNG 60 [in Polish].
14. Kuś J., Jończyk K., 1993. Ocena działania siedmiu czynników agrotechnicznych na plonowanie żyta [Evaluating the effect of seven agronomic factors on rye yielding]. Fragm. Agron. 4, 77-78 [in Polish].
15. Maciorowski R., Stankowski S., Piech M., Łapiński M., Stojałowski S., 1999. Żyto dla zaawansowanych [Rye for the advanced]. Top Agrar Polska 9, 45-50 [in Polish].

16. Mierzejewska W., 1985. Metody badawcze i miary oceny ekonomicznej efektywności chemicznych zabiegów ochrony roślin [Research methods and measurements to evaluate the economic effectiveness of chemical plant protection practises]. Post. Nauk Roln. 5, 77-90 [in Polish].
17. Pawlak J., 1989. Organizacyjne i ekonomiczne aspekty mechanizacji produkcji roślinnej w indywidualnych gospodarstwach rolniczych [Organisational and economic aspects of plant production mechanisation on private farms]. PWRiL Warszawa [in Polish].
18. Szempliński W., Kisiel R., 1998. Efektywność energetyczna różnych sposobów produkcji ziarna pastewnego jęczmienia jarego [Energy-effectiveness of various methods of spring barley fodder grain production]. Pam. Puł. 112, 237-243 [in Polish].
19. Szempliński W., Kisiel R., Budzyński W., 1998. Porównanie rolniczej, energetycznej i ekonomicznej efektywności różnych sposobów produkcji ziarna jęczmienia jarego [Comparison of agricultural, energetic and economic effectiveness of various spring barley grain production methods]. Rocz. AR w Poznaniu 307, 25-32 [in Polish].
20. Szulc J. Budzyński W., Szczebiot M., 2001. Comparison of high and low inputs technologies of hybrid and population cultivars rye production. Proc. Prosperity in Agriculture is a Science, Czech University of Agriculture in Prague, 213-217.
21. Wielicki W., 1989. Analiza efektywności energetycznej w rolnictwie [Analysis of energy-effectiveness in agriculture]. Post. Nauk Roln. 1, 69-86 [in Polish].
22. Zaremba W., 1986. Energetyka w systemie eksploatacji sprzętu rolniczego [Energetics in the agricultural equipment exploitation system]. PWRiL Warszawa [in Polish].

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