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ECONOMIC EFFICIENCY OF DIFFERENT WINTER RYE PRODUCTION TECHNOLOGIES

Key words: winter rye, cultivars, grain yield, production technology, economic effects

ABSTRACT. The aim of the study was to compare the production and economic effects of different winter rye depending on their production technologies. The study was carried out based on the results obtained from a field experiment conducted in two growing seasons (2018/2019 and 2019/2020). These experiments were conducted in Wielichowo Agricultural Experimental Station, belonging to the Institute of Soil Science and Plant Cultivation – the State Research Institute in Puławy (Poland). The result of the study was the determination of economic efficiency indicators for two cultivars of winter rye varieties according to production technology. The technologies differed in terms of the degree of consumption of means of production. The studies showed a significant influence of production technology intensity on the yields of winter rye cultivars. Intensive technology resulted in a significant increase in grain yield. The tested cultivars yielded higher under intensive production technology. The cultivation of winter rye according to intensive technology compared to integrated technology resulted in a significant increase in grain yield. The grain yield increase for the KWS Vinetto cultivar was 0.13 t/ha, while for the Dańkowskie Granat cultivar 0.20 t/ha. Research showed that the level of production intensity determined the amount of direct costs as well as the profitability of production in a given technology. The compared technologies ensured the profitability of winter rye grain production. Both production technologies ensured the profitability of production of the tested cultivars of winter rye. The most profitable direct profitability index was characteristic for the population cultivar Dańkowskie Granat grown under the integrated technology.

INTRODUCTION

The productivity and quality of agricultural produce depends on production technology [Nowak et al. 2013]. The usefulness of using production technology is assessed through economic evaluation [Krasowicz, Nowacki 2005, Harasim 2007]. There are many calculations aimed at showing the efficiency of cereal cultivation. It is primarily the size

of the grain yield, the purchase price as well as the level of intensity of the production technology that determine the profitability of cultivation [Dropka 2004, Nasalski et al. 2004]. In recent years, integrated technologies have been used in practice. They are aimed at combining appropriate agrotechnics with the limited consumption of industrial means of production, which is associated with minimizing the negative impact of agriculture on the environment [Kuś et al. 2007, Podolska, Sułek 2012]. The use of pesticides and fertilizers is reduced to a minimum (doses calculated on the basis of soil fertility) [Korbas, Mrówczyński 2009]. The technology of cereal production has a decisive role in the profitability of production, as cereals occupy over 70% of the sown area on farms [Nieróbca et al. 2008].

The aim of this study was the economic evaluation of different winter rye production technologies.

MATERIAL AND METHODS OF THE STUDY

The studies were carried out in two growing seasons: 2018/2019 and 2019/2020 at the Agricultural Experimental Station in Wielichowie, belonging to IUNG-PIB in Puławy. The experiment was located on soil of the good rye complex, in three replications, the size of the harvest plots was 650 m². The first order factor (A) was the production technology: intensive and integrated. The second order factor (B) was the winter rye cultivar: the KWS Vinetto (a hybrid cultivar) and the Dańkowskie Granat (a population cultivar). The extent of differences between production technologies is shown in Tables 1 and 2.

The amount of input of production means was determined on the basis of actual consumption in the experiment of fertilizers, seed and plant protection means. The costs of production means were determined on the basis of purchase prices, and the production value of winter rye was determined on the basis of the average purchase price of grains in 2021 – PLN 816 for 1 tonne of consumption rye grain (price on 30.09.2021).

For the economic evaluation of the investigated winter rye production technologies, the category of gross margin was used. The final stage of the economic calculation was the calculation of the direct profitability index as the ratio of the production value to incurred direct costs. For each technology, the volume of production balancing the direct costs expressed in the amount of grains necessary to cover those costs was also calculated. The conducted analysis of profitability was incomplete, as the category of gross margin did not take the indirect costs incurred during the production process into account.

Yield results were statistically analyzed using the two-factor analysis of variance (ANOVA) using the Statgraphics Centurion XVI computer program. The significance of differences between the means was evaluated using Tukey's test at a significance level $p = 0.05$.

Table 1. The characteristics of winter rye production technologies used

Development stage	Name of the means of production	Measure unit	Application rate in technology	
			intensive	integrated
Before sowing	Superphosphate (NPK)	kg/ha	200	133
	Potassium salt (K)		150	100
Emergence	Snajper 600 SC	l/ha	1.0	1.0
	Lentipur Flo 500 SC		1.0	1.0
Start of the growing season	Ammonium nitrate (N)	kg/ha	176	118
Stem formation	Stiff 250 EC	l/ha	0.3	-
Stem formation	Fossa 633 EC + Kosa 250 EW		1.2 + 0.25	-
Stem formation	Ammonium nitrate (N)	kg/ha	176	118
The flag leaf stage	Intizam 497 SC	l/ha	0.25	-

Source: own study

Table 2. Winter rye production technology parameters

Specification	Measure unit	Intensive technology		Integrated technology	
		KWS Vinetto	Dańkowskie Granat	KWS Vinetto	Dańkowskie Granat
Sowing amount	kg/ha	50	80	50	80
Seed cost	PLN/ha	510	160	510	160
Share in direct costs	%	22.89	8.52	33.12	13.45
Level of pure ingredient					
N	kg/ha	120	120	80	80
P ₂ O ₅		60	60	40	40
K ₂ O		90	90	60	60
Cost of fertilizers	PLN/ha	1,398	1,398	932	932
Share in direct costs	%	62.75	74.44	60.52	78.31
Plant protection products	PLN/ha	320	320	98	98
Share in direct costs	%	14.36	17.04	6.36	8.24

Source: own study

RESEARCH RESULTS AND DISCUSSION

Winter rye cultivars were grown in two production technologies, which were different in mineral fertilization and the consumption of plant protection chemicals. In direct costs, mineral fertilizers and plant protection chemicals constituted 77.11-91.48% in intensive technology, while in integrated technology – 66.88-86.55% (Table 2). The share of seed costs ranged from 8.52-22.89% in intensive technology to 13.45-33.12% in integrated technology. Differences in the level of direct inputs determined the profitability of winter rye. According to Dorota Dropka [2004], mineral fertilization is the most energy- and cost-intensive element of agrotechnics, and outlays borne in cereal production on mineral fertilization may even exceed 60%.

Winter rye obtained a significantly higher yield level when cultivated according to intensive technology (Table 3). For the population of the Dańkowskie Granat cultivar, the increase in grain yield was 0.20 t/ha, while for the hybrid KWS Vinetto cultivar, it was 0.14 t/ha as compared to integrated technology. The increase in grain yield was due to increased expenditure on mineral fertilization and plant protection products (Table 2). Also, Piotr Nieróbca et al. [2008] and Bogusława Jaśkiewicz [2015] state that, under

Table 3. Yields and chosen indicators of economic efficiency of winter rye cultivar production

Specification	Production technology			
	intensive		integrated	
	cultivar			
	KWS Vinetto	Dańkowskie Granat	KWS Vinetto	Dańkowskie Granat
Yield of grain [tonne/ha]	7.0 a	6.67 b	6.87 b	6.47 c
Productivity of N [kg grain/kg N]	58.3	55.6	85.9	80.9
Productivity of NPK [kg grain/kg NPK]	25.9	24.7	39.2	35.9
The value of production [PLN/ha]	5,712	5,443	5,606	5,280
Direct costs [PLN/ha]	2,228	1,878	1,540	1,190
Direct surplus without direct payment [PLN/ha]	3,484	3,565	4,066	4,090
Crop balancing direct costs [tonne]	2.73	2,30	1.89	1.46
Indicator of direct profitability without direct payment [%]	256.3	289.8	364.0	409.9

a, b, c – the different letters at the yield of the grain signify the significant difference

Source: own study

intensive production technology, cereals yield at a higher level. According to Bogusława Jaśkiewicz and Alicja Sułek [2018], lower grain yields of triticale under economic technology result from lower direct inputs (seed consumption, mineral fertilizers and plant protection products). As indicated by Alicja Sułek et al. [2016], intensive winter wheat production technology resulted in a higher grain yield compared to integrated and economic technologies, while yields were lower by 13 and 18%, respectively. Such a reduction in grain yield was also a result of a reduction in gross margin, as in intensive and integrated technologies, mineral fertilizers and plant protection products, which were the main components of direct costs. Also, the study of Alicja Sułek [2017] showed a significant effect of the intensity of production technology on the yield of winter wheat cultivars. Under conditions of intensive technology, all cultivars studied produced the highest grain yield. In the research that Ludwik Wicki [2017] conducted, the production technology determined changes in the yield level of winter wheat and rye. At higher levels of production intensity, grain yields of both cereal species were higher.

Significant differences were found in direct surplus, which is the difference between the yield value and direct costs for individual production technologies (Table 3). The lowest direct costs were incurred by applying integrated production when sowing the Dańkowskie Granat cultivar. The difference in direct costs between the applied production technologies resulted from reduced doses of fertilizers and plant protection products in integrated technology. According to Bogusława Jaśkiewicz and Alicja Sułek [2018], lower direct costs were incurred in conditions of economic production technology and the highest in the intensive one. The highest gross margin per 1 ha of winter rye cultivation was obtained under integrated technology conditions. It amounted to PLN 4,066 for the KWS Vinetto cultivar and PLN 4,090 for the Dańkowskie Granat cultivar. With reference to intensive production technology, these margins were higher by 14.31% and 12.84%, respectively. The study by Alicja Sułek et al. [2016] also indicates the lowest gross margins when using economic technology, and the highest when using intensive technology. On the other hand, Piotr Nieróbca et al. [2008] found that the level of gross margin was not proportional to the yield level of winter triticale in both technologies and for both cultivars. In the study by Alicja Sułek [2017], the lowest direct costs were incurred when using economic technology (the difference was due to the reduction of fertilizer rates and plant protection treatments).

A very important element of production technology assessment is its profitability, which is the relation of the production value to direct costs. In the presented studies, the high profitability of winter rye production was obtained for both technologies and cultivars. The highest production profitability was achieved by the population of the Dańkowskie Granat cultivar (409.9%) grown under integrated technology. The least favourable profitability index was recorded for the KWS Vinetto hybrid cultivar (256.3%), grown at a higher agrotechnical level. Grażyna Podolska et al. [1996] and Aleksander Szmigiel et al. [2006]

indicate the highest profitability of wheat production at low-input technology without the use of chemical plant protection. In turn, Jerzy Grabiński et al. [2015] obtained higher production profitability using integrated technology (compared to intensive technology). A study by Alicja Sułek [2017] found that growing winter wheat under intensive, integrated and economic technologies, ensured the profitability of production.

SUMMARY

Winter rye cultivation under intensive technology, compared to integrated technology, caused a significant increase in grain yield. For the KWS Vinetto cultivar, the increase in grain yield was 0.13 t/ha, while for the Dańkowskie Granat cultivar it was 0.20 t/ha.

The level of technology intensity determined by the input of production means determined the structure of direct costs and profitability of winter rye production. The highest direct surplus per 1 ha was obtained for winter rye cultivars grown under integrated technology. For the KWS Vinetto cultivar, it was higher by 14.31%, while for the population of the Dańkowskie Granat cultivar by 12.84%, compared to that obtained in integrated technology. The compared production technologies ensured the profitability of winter rye cultivar production. The most favorable index of direct profitability was noted for the population of the Dańkowskie Granat cultivar grown under integrated technology.

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EFEKTY PRODUKCYJNE I EKONOMICZNE W ZALEŻNOŚCI OD TECHNOLOGII PRODUKCJI ŻYTA OZIMEGO

Słowa kluczowe: żyto ozime, odmiany, plon ziarna, technologia produkcji,
efekt ekonomiczny

ABSTRAKT

Celem badań było porównanie efektów produkcyjnych i ekonomicznych różnych technologii produkcji żyta ozimego. Podstawę opracowania stanowiły wyniki przeprowadzonych w dwóch sezonach wegetacyjnych (2018/2019 i 2019/2020) eksperymentów polowych. Eksperymenty te były prowadzone w Rolniczym Zakładzie Doświadczalnym w Wielichowie, należącym do Instytutu Uprawy Nawożenia i Gleboznawstwa – Państwowego Instytutu Badawczego w Puławach. Rezultatem przeprowadzonych badań było określenie wskaźników efektywności ekonomicznej dla dwóch odmian żyta ozimego w zależności od technologii produkcji. Technologie różniły się między sobą stopniem zużycia środków produkcji. Z przeprowadzonych badań wynika, że poziom intensywności technologii produkcji żyta ozimego miał istotny wpływ na plonowanie badanych odmian. Technologia intensywna powodowała znaczny wzrost plonu ziarna. Badane odmiany plonowały wyżej w warunkach intensywnej technologii produkcji. Badania również wykazały, że poziom intensywności produkcji decydował o wielkości kosztów bezpośrednich, a także o opłacalności produkcji w danej technologii. Najniższe koszty produkcji stwierdzono przy technologii integrowanej wysiewając odmianę populacyjną żyta – Dańkowskie Granat. Obie technologie produkcji zapewniały opłacalność produkcji badanych odmian żyta ozimego. Pomimo wyższych plonów ziarna przy zastosowaniu technologii intensywnej, technologia integrowana okazała się bardziej opłacalna.

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