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ECONOMIC EVALUATION OF SPRING WHEAT PRODUCTION TECHNOLOGY WITH DIFFERENT INTENSITY LEVELS

Key words: spring wheat, cultivars, grain yield, intensity of technology, efficiency, Gross Margin

ABSTRACT. The aim of the study was to compare the productive and economic effects of different production intensities of spring wheat. The study was based on the results of a two-year (2015-2016) field study, conducted at the Agricultural Experimental Station in Osiny, belonging to the Institute of Soil Science and Plant Cultivation in Pulawy. Spring wheat cultivars (Arabella and KWS Torridon) were grown using intensive and integrated technologies. The technologies studied differed in the level of mineral fertilization and chemical plant protection. The cultivation of spring wheat of the KWS Torridon cultivar according to intensive technology, as compared with cultivation under conditions of integrated technology, resulted in a significant increase in grain yield by 10.6%, respectively. On the other hand, no effect of production technology was found on the yield of the Arabella cultivar. The research showed that the technology intensity level, determined by inputs of production means, determined the structure of direct costs and profitability of spring wheat cultivars. The compared technologies ensured the profitability of spring wheat grain production. The most advantageous index of direct profitability was recorded for the Arabella cultivar grown under integrated technology.

INTRODUCTION

Of the spring cereals grown, wheat plays a special role in the food economy. It is most often used for consumption. Since wheat is a basic consumption cereal, it should be considered a plant of strategic importance for Polish agriculture. Grain yields of spring wheat compared to winter wheat are lower but of better quality [Cacak-Pietrzak et al. 2014, Kocoń 2005]. Due to the higher content of protein substances, the grain of spring wheat

cultivars is a good raw material to produce baking flours and as a component improving the technological value of milling mixtures. Research on production technologies of this species is particularly justified. At an intensive level of agrotechnology usually better production effects are obtained, despite higher costs incurred for cultivation [Nowak et al. 2013, Kołodziejczyk et al. 2007]. Intensive technologies use large amounts of mineral fertilizers and plant protection products, which translates into higher costs, as well as environmental pollution. Hence, the need to introduce integrated technology. The integrated production of wheat has a special place in an integrated production system. In this system of production, despite reduced inputs, yields are not always lower, but costs are certainly lower than in intensive production. Integrated technology is safer for the environment [Kuś, Jończyk 2009].

The ultimate goal of any production technology used in practice is to obtain better economic indicators. Economic evaluation is necessary to apply such a technology in practice [Krasowicz, Nowacki 2005]. In economic evaluation, only direct costs can be considered, based on an incomplete, simplified calculation [Harasim 2012, Krasowicz 1999]. A consequence of limiting assessment to direct costs is the calculation of the direct surplus as the difference between the value of grain harvested from 1 ha and the incurred direct costs of industrial means of production.

The objective of this study was to compare the production and economic effects of different spring wheat production technologies.

MATERIAL AND METHODS OF THE STUDY

The study was conducted between 2015-2016 at the Agricultural Experimental Station in Osiny, belonging to the Institute of Soil Science and Plant Cultivation in Puławy. The first factor was the type of technology: integrated and intensive (A), which were differentiated in terms of mineral fertilizer doses and intensity of chemical plant protection. The second factor were Arabella and KWS Torridon cultivars (B). A summary of crop management treatments is presented in Table 1.

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

The number of inputs of production means was determined based on actual consumption in the experience of fertilizers, seed and plant protection products. The costs of production means were determined based on purchase prices, and the value of winter wheat production was determined according to the average grain purchase price in 2021. The grain production calculations assumed the purchase price of PLN 940 for 1 t of quality wheat grain in the 3rd quarter of 2021. For the economic evaluation of researched technologies of spring wheat

Table 1. Characterization of applied technologies for spring wheat production

Plant development phase*	Means of production (active substance)	Unit of measure	The dose of the means of production	
			intensive	integrated
Before sowing	Potassium salt (K)	kg/ha	100	105
	Superphosphate (P)		80	50
	Ammonium nitrate (N)		60	50
BBCH 31	Ammonium nitrate (N)		60	40
BBCH 51	Ammonium nitrate (N)		40	20
BBCH 31	Mustang Forte 195 SE (Florasulam, aminopyralid, 2,4 D)	l/ha	1.0	1.0
BBCH 36	Moddus 250 EC (Trineksapak etylu)		0.4	-
BBCH 41	Imput 460 EC (protiokonazol, spiroksamina)		1.0	-
BBCH 51	Fury 100 EW (zeta-cypermetryn)		0.1	0.1
BBCH 57	Amistar 250 SC (azoksystrobina)		-	0.4
BBCH 57	Artea 330 EC + Amistar 250 S.C. (azoksystrobina + propikonazol cyprokonazol)		0.4 + 0.6	-

* BBCH – scale, plant development phase
Source; own study

production, the category of direct surplus was used. The direct surplus from the activity (in this case, the cultivation of durum wheat), according to the methodology of the European Union (EU), is the annual value of production obtained from 1 ha of cultivation minus the direct costs incurred to produce this production [Nowak et al. 2013]. The final stage of the economic account was the calculation of the direct profitability index as the ratio of the value of production to the direct costs incurred. For each technology, the volume of production balancing the direct costs expressed in the amount of grain necessary to cover these costs was also calculated. The profitability analysis was incomplete, as the direct surplus category did not take the indirect costs incurred during the production process into account.

RESEARCH RESULTS AND DISCUSSION

Spring wheat cultivars were grown using two production technologies which differed in mineral fertilization and the use of chemical plant protection chemicals. The range of differences between production technologies is presented in Tables 1 and 2. In direct costs, mineral fertilizers and plant protection chemicals constituted 80.0% in intensive technology, and 71.0% in integrated technology (Table 2). The share of seed costs in intensive technology for Arabella was 25.5% and for integrated technology it was 32.4.%, while for KWS Torridon it was 43.2% and 51.6%, respectively. Differences in the level of direct inputs determined the profitability of spring wheat cultivar production. Among agrotechnical factors, mineral fertilization is the most energy- and cost-intensive element of agrotechnics and may even exceed 60% of inputs incurred in cereal production [Dropka 2004].

The cultivar KWS Torridon yielded higher under intensive technology conditions. The grain yield increase was 0.74 t/ha compared to the yield obtained in integrated technology. (Table 3). On the other hand, no effect of the studied production technologies on the yield of Arabella wheat was found. Alicja Sułek and Grażyna Podolska [2012] showed that spring wheat cultivars react differentially to increasing intensity of production technology.

Table 2. Summary of parameters of Arabella and KWS Torridon spring wheat production technology

Specification	Unit of measure	Intensive technology		Integrated technology	
		Arabella	KWS Torridon	Arabella	KWS Torridon
Seeding rate	kg/ha	176	191	176	191
Seed cost	PLN/ha	739.2	1,642.6	739.2	1,642.6
Share in direct costs	%	25.5	43.2	32.5	51.6
Mineral fertilizers					
N	kg/ha	160	160	110	110
P_2O_5		80	80	50	50
K_2O		100	100	105	105
Fertilizer cost	PLN/ha	1,697	1,697	1,362	1,362
Share in direct cost	%	58.6	44.7	59.7	42.8
Plant protection agents	l/ha	460.1	460.1	179,1	179.1
Share in direct costs	%	15.9	12.1	7.8	5.6

Source; own study

A significantly higher grain yield was recorded for Nawra and Bombona cultivars grown under intensive technology compared to integrated technology, the grain yield surplus amounting to 21.6%. The effect of production technology intensity on yields of spring wheat cultivars is also proved by research conducted by Marek Kołodziejczyk et al. [2007]. The highest increase in grain yield was observed for Żura and Nawra cultivars. The weakest response to the agrotechnical level was recorded for Napola.

The efficiency of mineral fertilization depended on the applied production technology (Table 3). Wheat grain yield per 1 kg of nitrogen applied in mineral fertilizers was higher under integrated than intensive technology conditions. When all fertilizer components were considered, the difference between intensive and integrated technology in terms of productivity per 1 kg of NPK for the Arabella cultivar was 5.5%, while for KWS Torridon it was 3.6% (Table 3).

The direct surplus, which is the difference between the value of grain yield and direct costs calculated for individual production technologies and spring wheat cultivars, showed definite differences (Table 3). Comparison of data in Table 3 and Figure 1 shows that higher direct costs were incurred when intensive technology was used. The difference in direct costs was mainly due to a reduction in mineral fertilizers in integrated technology and a reduction of plant protection treatments compared to those applied in intensive technology.

Table 3. Grain yield and other indicators of economic efficiency of spring wheat production

Specificationn	Production technology			
	intensive		integrated	
	variety			
	Arabella	KWS Torridon	Arabella	KWS Torridon
Grain Yield	6.54a*	7.71b	6.54a	6.97a
Productivity of N [kg grain/kg N]	40.9	48.2	59.5	63.4
Productivity of NPK [kg grain/kg NPK]	19.2	22.7	24.7	26.3
The value of production [PLN/ha]	6,147.6	7,247.4	6,147.6	6,551.8
Direct costs [PLN/ha]	2,896.3	3,799.7	2,280.3	3,183.6
Direct surplus without direct payment [PLN/ha]	3,251.3	3,447.7	3,867.3	3,368.2
Crop balancing direct costs [t]	3.1	4.0	2.4	3.4
Indicator of direct profitability without direct payment [%]	212.3	190.7	269.6	205.8

* The same letter at the digit defining grain yield signifies a lack of a significant difference

Source; own study

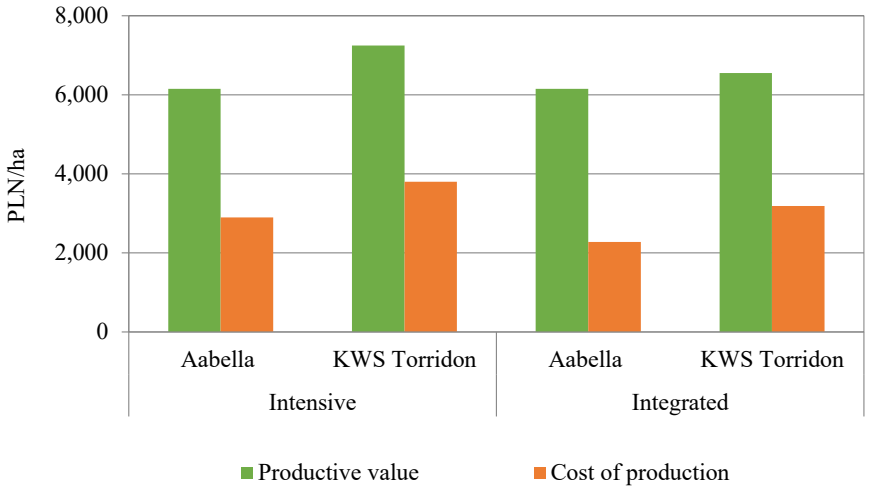

Figure 1. Impact of production intensity on production value and incurred direct cost
Source: own study

The highest direct surplus per 1 hectare was recorded for the Arabella cultivar grown according to integrated technology (PLN 3,867.3). It was higher by 16.0% than the surplus achieved under intensive technology conditions. On the other hand, the KWS Torridon cultivar showed the highest direct surplus under intensive cultivation (PLN 3,447.7), but its increase was only 2.3% with respect to integrated technology.

Anna Nowak et al. [2013] also showed that spring wheat had a higher direct surplus on lower intensity technology, which was related to the high cost of mineral fertilization that was not compensated by the yield obtained. Other studies on spring durum wheat found a higher direct surplus from 1 ha of cultivation with intensive technology (PLN 3,896), which was 18.6% higher compared to the result obtained with medium intensive technology [Sułek, Wyzińska 2019]. An important measure of technology evaluation is the profitability of production, which is the relation of production value to direct costs (Table 3). Production profitability of spring wheat cultivars, in the compared technologies, was high. In own studies, the highest value of this index was achieved by the Arabella cultivar grown in integrated technology (260.6%) (Table 3). Grażyna Podolska and co-authors [1996], Alicja Sułek and co-authors [2016], as well as Aleksander Szmigiel and co-workers [2006] obtained the highest profitability of wheat production in low-input technology, where limited plant protection and lower mineral fertilization were applied.

SUMMARY

Profitability and advisability of spring wheat cultivation are determined not only by incurred costs, but also by sales prices, environmental conditions and production amount. The cultivation of the spring wheat cultivar KWS Torridon according to intensive technology, as compared with cultivation under conditions of integrated technology, caused a significant increase in grain yield by 10.6%, respectively. On the other hand, no effect of production technology was found on the yield of the Arabella cultivar. The highest direct surplus per 1 hectare was recorded for the Arabella cultivar grown under integrated technology. It was higher by 18.9% than that obtained in intensive technology. On the other hand, the KWS Torridon cultivar obtained the highest direct surplus in intensive cultivation, but its increase was only 2.3% compared with integrated technology. The compared technologies ensured the profitability of spring wheat grain production. The most favorable index of direct profitability was recorded for the Arabella cultivar grown under integrated technology.

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OCENA EKONOMICZNA TECHNOLOGII PRODUKCJI PSZENICY JAREJ O RÓŻNYM POZIOMIE INTENSYWNOŚCI

Słowa kluczowe: pszenica jara, odmiany, plon ziarna, intensywność technologii, efektywność, nadwyżka bezpośrednia

ABSTRAKT

Celem badań było porównanie produkcyjnych i ekonomicznych skutków różnej intensywności produkcji pszenicy jarej. Opracowanie wykonano na podstawie wyników dwuletnich (2015-2016) badań polowych, które były przeprowadzone w Rolniczym Zakładzie Doświadczalnym w Osinach, należącym do Instytutu Uprawy nawożenia i Gleboznawstwa w Puławach. Odmiany pszenicy jarej (Arabella i KWS Torridon) uprawiano, stosując technologię intensywną i integrowaną. Technologie różniły się poziomem nawożenia mineralnego i chemicznej ochrony roślin. W celu ekonomicznej oceny badanych technologii produkcji pszenicy jarej posłużono się kategorią nadwyżki bezpośredniej. Uprawa pszenicy jarej odmiany KWS Torridon według intensywnej technologii, w porównaniu z prowadzoną w warunkach technologii integrowanej, powodowała istotne zwiększenie plonu ziarna odpowiednio o 10,6%. Natomiast nie stwierdzono wpływu technologii produkcji na plonowanie odmiany Arabella. Badania wykazały, że poziom intensywności technologii wyznaczony przez nakłady ponoszone na środki produkcji, decydował o strukturze kosztów bezpośrednich i opłacalności odmian pszenicy jarej. Porównywane technologie zapewniały opłacalność produkcji ziarna pszenicy jarej. Najkorzystniejszym wskaźnikiem opłacalności bezpośredniej cechowała się odmiana Arabella uprawiana według technologii integrowanej.

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