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THE ECONOMIC EFFICIENCY OF PRODUCTION OF A TRITICALE HYBRID GENETIC LINE AT DIFFERENT LEVELS OF INTENSITY

Key words: winter triticale, cultivars, grain yield, nitrogen fertilization, tillage, efficiency, gross margin

ABSTRACT. The aim of the study was to evaluate the economic efficiency of production of a hybrid genetic line of winter triticale in comparison with a short-straw form, at different intensity levels under cereal crop rotation conditions. Calculations were made based on three-year (2017-2019) field trial results. The analysis included tillage methods (traditional and simplified), differentiated nitrogen fertilization (0.90 and 120 kg N/ha) and two forms of triticale: The rotondo variety and the hybrid genetic line – BOH 2415. The gross margin was taken as a measure of economic efficiency. The economic effectiveness of cultivation of both forms of winter triticale was assessed from the perspective of utilizing one of the basic production factors, i.e., land. The gross profitability index for particular variants of the experiment was also calculated as the relation of production value to direct costs. The analysis of production and economic indices showed that the more favorable variant of winter triticale cultivation was hybrid form cultivation technology with the use of traditional tillage (plough) and a nitrogen fertilization rate at a level of 120 kg N/ha. The level of the obtained gross margin was more influenced by the level of the obtained yield and the purchase price of triticale than by the level of incurred direct costs depending on the soil tillage method.

INTRODUCTION

The area of triticale cultivation in Poland is the largest among all countries in the world. By 2015, the area of its cultivation in the country increased to 1.52 million ha [GUS 2020]. In 2019, triticale occupied 16.7% of cereal acreage. Triticale is, primarily, a fodder cereal with a high nutritional value of grains [Djekic et al. 2011, Jaśkiewicz, Szczepanek 2018].

One of the important elements of production technology is mineral fertilization, mainly with nitrogen [Mut et al. 2005, Knapowski et al. 2009]. In agriculture, it plays a productive role, contributing to yield increase. Determining optimal rates of nitrogen fertilization for triticale is difficult because of the uneven response of cultivars [Jaśkiewicz 2010]. Breeding progress in recent years and, among others, the introduction of hybrid cultivars (F1) to the selection, may have contributed to better nitrogen utilization [Broda et al. 2005]. The yield is better in comparison with population varieties, are characterized by a higher tolerance to difficult habitat conditions and abiotic stresses. They also tiller better and have a better developed root system than population forms.

Tillage aims to optimize soil productivity by changing the physical, chemical and biological properties of the soil. Reduced tillage can cause nutrient accumulation in the topsoil, which is important for plant growth and development [Smagacz 2012]. In a study by Johan Arvidsson [2013], conducted between 1983 and 2012, it was shown that reduced tillage, compared to plough tillage, results in yield reduction by several percent.

The profitability of triticale production, besides yield size, is determined by grain purchase prices and the level of production technology intensity. The latter is measured by direct costs, reflecting, in value terms, the consumption of production inputs, such as seeds, mineral fertilisers and plant protection products [Krasowicz 2014]. The high prices of production inputs, with relatively low prices of agricultural products, lead to a search for technologies that ensure the highest production efficiency [Szpunar-Krok 2011]. The appropriate selection of production technology, matched to soil and climatic conditions, is the basic element of improving production profitability [Klikocka et al. 2011].

The aim of this study was to evaluate the economic efficiency of production of a hybrid genetic line of winter triticale in comparison with a short-straw form at different intensity levels under cereal crop rotation conditions.

MATERIALS AND METHODS

The experiments were conducted at the Agricultural Experimental Station of the Institute of Soil Science and Plant Cultivation (IUNG-PIB), in Osiny, in 2017-2019, as part of long-term cereal crop rotation on soil classified as a good wheat complex. Research was conducted on plots with an area of 35 m^2.

The first factor of the experiment was the tillage system, i.e., traditional (ploughing) and simplified (no-tillage). In plough tillage, after harvesting the forecrop, straw was crushed, and a disc aggregate was used. Subsoiling was done to a depth of 8-10 cm. Then, the soil was harrowed with a heavy harrow, and sown to a depth of 3-4 cm. In the reduced tillage system, after chopping the straw, the disc aggregate was used twice, followed by active cultivation and sowing to a depth of 3-4 cm. In both tillage systems, triticale grains were harvested with a combine and the straw was crushed (Table 1).

Table 1. Agro-technical treatments, including tillage, depending on the tillage type

Conventional (plough) cultivation	Reduced tillage (no-tillage)
Disc cultivation (3 m), NH110-90DT tractor (0.53 cnh)	
Ploughing with a 4-plow rotary plough (1.6 m), NH TM150 tractor (1.19 cnh)	Disc cultivation (3 m), NH 110-90DT tractor (0.53 cnh)
PK fertilisation, a spreader (12 m), a Zetor 7011 tractor (0.67 cnh)	
Tillage with a heavy harrow (5.3 m), Zetor 7011 tractor (0.53 cnh)	Cultivation and sowing with Becker cultivator + Amazone seed drill (3 m), NH110-90DT tractor (0.91 cnh)
Sowing, Amazone seed drill (3 m), Zetor 7011 tractor (0.91 cnh)	
N fertilization (50%), a spreader (12 m), Zetor 7011 tractor (0.67 cnh)	
Crop protection (12 m sprayer), Zetor 7011 tractor (0.67 cnh)	
N fertilization (50%), a spreader (12 m), Zetor 7011 tractor (0.67 cnh)	
John Deere W540 combine harvester with a forage harvester (5.5 m) (0.74 kmbh)	

Source: own analysis

The second factor of the study was the dose of nitrogen fertilization, i.e.: 0, 90, 120 kg/ha. 50% of the total dose of nitrogen fertilization was applied at the start of vegetation and the next 50% at the stage of stem shooting (BBCH 30-31), in the form of 34% ammonium nitrate.

The third factor of the study was the short-haired winter triticale cultivar Rotondo (Strzelce Plant Breeding) and the hybrid genetic line – BOH 2415 (Danko Plant Breeding).

Sowing was done at an optimum date for local conditions, at 128 kg/ha for BOH 2415 and 168 kg/ha – Rotondo. Phosphorus and potassium fertilization was applied before sowing the triticale at a rate of 60 kg/ha P_2O_5 and 90 kg/ha K_2O.

Protective treatments against pests were applied after they exceeded economic harmfulness thresholds [Korbas, Mrówczyński 2011]. The protection of triticale against insecticides was limited to one spray, while herbicides and fungicides were applied twice on two triticale cultivars.

The production-economic evaluation was carried out in a simplified manner. The average grain yield for the years 2017-2019 were used as the main criteria for assessing production efficiency.

The calculations of direct costs took the actual input incurred according to experimental instructions into consideration. All calculations were made in terms of 1 ha. The labor input was determined based on technological cards kept at an Agricultural Experimental Station IUNG, considering cultivation activities and treatments according to experimental instructions (Table 1 and 2).

Table 2. Use of seeds, mineral fertilizers and plant protection products

<table>
<tr><th rowspan="2">Specification</th><th colspan="4">Form of triticale</th></tr>
<tr><th colspan="2">the mesenchyme genetic line</th><th colspan="2">the semi-dwarf</th></tr>
<tr><td>The seed sowing rate (actual) [kg/ha]</td><td colspan="2">128</td><td colspan="2">168</td></tr>
<tr><td colspan="5">The fertilizer application rate [kg/ha]:</td></tr>
<tr><td>- potassium (potassium salt)</td><td colspan="4">90</td></tr>
<tr><td>- phosphorus (superphosphate)</td><td colspan="4">60</td></tr>
<tr><td>- nitrogenous (ammonium nitrate)</td><td>0</td><td colspan="2">90</td><td>120</td></tr>
<tr><td>Herbicides</td><td colspan="4">Bizon (1.0 l/ha)
Mustang Forte 195 SE (0.5 l/ha)
Puma Uniwersal 069 EW (1.0 l/ha)</td></tr>
<tr><td>Fungicides</td><td colspan="4">Unix 75WG (0,6 kg/ha)
Tilt Turbo 575 EC (0.6 kg/ha)
Elatus Era (1.0 l/ha)</td></tr>
<tr><td>Insecticides</td><td colspan="4">Fury 100 EW (0.1 l/ha)</td></tr>
<tr><td>Anti-sticker</td><td colspan="4">Moddus 250 EC (0.4 l/ha)</td></tr>
</table>

Source: own analysis

The analysis also considered the effect of differentiated nitrogen fertilization (0, 90 and 120 kg N/ha) and tillage methods (traditional and simplified) on the productive and economic efficiency of tillage technology for triticale forms, by calculating fuel consumption costs according to the formula proposed by Harasim [2006]. Fuel costs were calculated as the product of tractor power expressed in kW, the coefficient defining fuel consumption per unit of power (0.110 g/kW), and the fuel price expressed in PLN/liter. For the conversion of fuel quantity from kilograms to liters, the density of diesel was used (0.83 g/cm^3).

The value of triticale grain production from 1 ha and direct production costs were expressed in prices from the first half of 2021. For the triticale grain yield, the price of PLN 816 per 1 ton was assumed, and for qualified material PLN 1,800 per 1 ton for semi-dwarf triticale and PLN 3,000 per 1 ton for hybrid triticale. The price of 1 liter of diesel fuel was assumed as follows 5.03 zł/liter[1].

Taken as a measure of economic efficiency, the gross margin (N_b) was calculated as the difference between the harvested value (W) of grains and direct costs (K).

1 Price based on weekly quotations by Bankier.pl [https://www.bankier.pl/gospodarka/wskazniki-makroekonomiczne/on-pol].

The economic effectiveness of cultivation of both forms of winter triticale was evaluated from the perspective of utilizing one of the basic production factors: land (the gross margin in PLN/ha). The gross profitability index for particular variants of the experiment was also calculated as the relation of the production value (W) to direct costs (K) (including the value of consumed fuel).

RESULTS AND DISCUSSION

Analysis of production and economic data, summarized in Table 3, showed that the most advantageous variant of winter triticale cultivation was hybrid form cultivation technology with the use of traditional soil cultivation (ploughing) and a nitrogen fertilization rate at a level of 120 kg N/ha (Table 3). It achieved the highest grain yield (8.31 t/ha) and, thus, the highest value of harvested yield (6,781 PLN/ha). This technology, due to the tillage method requiring the highest number of harvests and, thus, the highest fuel consumption and the highest level of nitrogen fertilization (120 kg N/ha), had the highest direct costs of 3,082 PLN/ha. Despite that, in this variant, the highest value of the gross margin was obtained (3,699 PLN/ha), as well as the highest value of the profitability index – 220%.

Among technologies, in which mineral nitrogen fertilization was used, the technology of cultivating the dwarf form of winter triticale with the application of simplified tillage and nitrogen fertilization at a level of 90 kg/ha proved to be the least favorable variant (Table 3). In this technology, the yield level of triticale was 6.47 t/ha, and the value of the obtained yield was 5,280 PLN/ha. From among the analyzed group, this technology brought the lowest value of direct costs (2,766 PLN/ha), however also the lowest value of the gross margin (2,514 PLN/ha) and the lowest profitability index – 191% (comparable for the technology of cultivating the hybrid form of triticale with identical soil tillage and level of applied nitrogen fertilization).

For both analyzed forms of winter triticale, similar relationships between experimental factors (the soil tillage and nitrogen fertilization level) and production and economic indices, were observed. The technologies with traditional (plough) tillage were characterized by higher triticale yield, irrespective of the level of applied mineral nitrogen fertilization. Thus, they were characterized by a higher value of obtained yield – the production value. These technologies also brought higher direct production costs (including the value of fuel used), irrespective of the level of nitrogen fertilization. The level of the obtained gross margin reached higher values in variants of technologies with plough tillage, irrespective of the level of nitrogen fertilization. Similar relations also concerned the profitability index. In the study by Bogusława Jaśkiewicz and Alicja Sułek [2018], carried out with triticale of different production intensity, analysis of the gross margin value showed the advantage of technologies with a higher level of intensity over technologies with a lower

Table 3. Selected productive and economic indicators of cultivation of the triticale hybrid genetic line – BOH 2415 and semi-dwarf form - Rotondo at different levels of nitrogen fertilization and under different tillage systems

Specification	Hybrid genetic line – BOH 2415						Semi-dwarf mould – Rotondo					
	conventional (plough) cultivation			reduced tillage (no-tillage)			conventional (plough) cultivation			reduced tillage (no-tillage)		
	nitrogen fertilization [kg N/ha]											
	0	90	120	0	90	120	0	90	120	0	90	120
The grain yield [t/ha]	3.45	7.29	8.31	3.07	6.69	7.91	3.12	6.83	7.94	2.88	6.47	7.66
The value of harvested grain [PLN]	2,815	5,949	6,781	2,505	5,459	6,455	2,546	5,573	6,479	2,350	5,280	6,251
Direct costs [PLN], including:	2,357	2,910	3,082	2,295	2,848	3,020	2,275	2,828	3,000	2,213	2,766	2,938
- nitrogen fertilisation*	0	553	725	0	553	725	0	553	725	0	553	725
- tillage and sowing**	168			106			168			106		
The gross margin [PLN]	458	3,039	3,699	210	2,611	3,435	271	2,745	3,479	137	2,514	3,313
Grain yield offsetting direct costs [t/ha]	2.89	3.57	3.78	2.81	3.49	3.70	2.79	3.47	3.68	2.71	3.39	3.60
The rate of direct profitability without subsidies [%]	119	204	220	109	192	214	112	197	216	106	191	213

* including application costs in terms of the fuel used
** in the form of the cost of fuel used
Source: own analysis

use of production means. In other research conducted by Bogusława Jaśkiewicz [2006], cultivating the semi-dwarf form of triticale, in comparison with the traditional form, ensured a higher economic effectiveness of the use of basic production factors.

It was also observed that the values of the analyzed production and economic indices (the yield, the production value, direct costs, the gross margin and the profitability index) increased with increasing levels of nitrogen fertilization, irrespective of the tillage method used (Table 3).

In the conducted economic analysis of the effect of the tillage method in winter triticale cultivation on the level of the obtained gross margin, a bigger effect was exerted by the level of the triticale yield, and after considering high purchase prices – by the value of the obtained production. It ranged from 228 PLN/ha (dwarf form and fertilization at 120 kg N/ha) to 490 PLN/ha (hybrid form and fertilization at 90 kg N/ha). Their difference between particular tillage methods (irrespective of the level of fertilization and the cultivated form of triticale) amounted to 62 PLN/ha.

SUMMARY

With respect to the analyzed production and economic indices (the yield, the gross margin and the profitability index), the most favorable variant of winter triticale cultivation was the hybrid cultivation technology with the use of conventional (plough) tillage and a nitrogen fertilization rate at a level of 120 kg N/ha.

In the conducted economic analysis of the effect of the tillage method in winter triticale cultivation on the level of the obtained gross margin, a bigger effect was exerted by the level of the obtained yield and the purchase price of triticale than by the level of incurred direct costs depending on the tillage method.

BIBLIOGRAPHY

Arvidsson Johan. 2013. Crop yield in Swedish experiments with shallow tillage and no-tillage 1983-2012. *European Journal Agronomy* 52: 307-315.

Broda Zbigniew, Agnieszka Tomkowiak, Danuta Mackiewicz, Anita Dobek, Henryk Woś, Roman Warzecha, Krystyna Warzecha. 2005. Analiza zróżnicowania linii pszenżyta przydatnych do hodowli mieszańców przy użyciu markerów molekularnych (Molecular marker based study of genetic diversity of triticale lines suitable for hybrid breeding). *Biuletyn IHAR* 237/238: 83-92.

Djekic Vera Radomir, Sreten Mitrovic, Milivoje Milovanovic, Nenad Djuric, Branka Kresovic, Angelina Tapanarova, Vladan Djermanovic, Marko Mitrovic. 2011. Implementation of triticale in nutrition of non-ruminant animals. *African Journal of Biotechnology* 10 (30): 5697-5704. DOI: 10.5897/AJB10.986.

GUS (Central Statistical Office). 2020. *Rocznik statystyczny* (Statistical yearbook). Warszawa: PWN.

Harasim Adam. 2006. *Przewodnik ekonomiczno-rolniczy w zarysie* (An outline economic and agricultural guide). Puławy: IUNG.

Jaśkiewicz Bogusława 2006. Ekonomiczna efektywność produkcji półkarłowej formy pszenżyta ozimego (Economic effectiveness of cultivation of semi-dwarf form of winter triticale). *Pamiętnik Puławski* 142: 163-169.

Jaśkiewicz Bogusława 2010. Wpływ nawożenia azotem na plonowanie i zawartość białka w ziarnie odmian pszenżyta ozimego (Effect of nitrogen fertilization on yielding and protein content in grain of winter triticale cultivars). *Fragmenta Agronomica* 31 (1): 25-31.

Jaśkiewicz Bogusława, Alicja Sułek. 2018. Ocena ekonomiczna technologii produkcji pszenżyta ozimego o różnym poziomie intensywności (Economic evaluation of production technology of winter triticale at different level of intensity). *Roczniki Naukowe SERiA* XX (5): 69-73. DOI:10.5604/01.3001.0012.6683.

Jaśkiewicz Bogusława, Małgorzata Szczepanek. 2018. Amino acids content in Triticale grain depending on meteorological, agrotechnical and genetic factors. Proceedings of 24th Annual International Scientific Conference. *Research for Rural Development 2018* 2: 28-35. DOI: 10.22616/rrd.24.2018.047.

Klikocka Hanna, Aleksandra Głowacka, Dariusz Juszczak. 2011. Wpływ zróżnicowanych sposobów uprawy roli i nawożenia mineralnego na efekty ekonomiczne uprawy jęczmienia jarego (The influence of different soil tillage methods and mineral fertilization on the economic parameter of spring barley). *Fragmenta Agronomica* 28 (2): 44-54.

Knapowski Tomasz, Maria Ralcewicz, Bożena Barczak, Wojciech Kozera. 2009. The effect of fertilization with nitrogen and zinc on the bread-making quality of spring triticale cultivated in the Noteć Valley. *Polish Journal of Environmental Studies* 18: 227-233.

Korbas Marek, Marek Mrówczyński. 2011. *Metodyka integrowanej ochrony pszenżyta ozimego i jarego* (Methodology of integrated protection of winter and spring triticale). Poznań: IOR.

Krasowicz Stanisław. 2014. Badania naukowe jako wsparcie konkurencyjności polskiego rolnictwa (Research as a support for the competitiveness of Polish agriculture). *Roczniki Naukowe SERiA* XVI (1): 117-123.

Mut Zeki, Ismail Sezer, Ali Gulumser. 2005. Effect of different sowing rates and nitrogen levels on grain yield, yield components and some quality traits of triticale. *Asian Journal Plant Sciences* 4: 533-539. DOI: 10.3923/ajps.2005.533.539.

Smagacz Janusz. 2012. Produkcyjno-ekonomiczne i środowiskowe skutki różnych systemów uprawy roli (Production, economic and environmental effects of different farming systems). *Studia i Raporty IUNG-PIB* 29 (3): 121-135.

Szpunar-Krok Ewa. 2011. *Produkcyjne i ekonomiczne efekty wybranych technologii produkcji nasion roślin strączkowych w siewie czystym i ich mieszanek ze zbożami. Rozprawa habilitacyjna* (Production and economic effects of selected technologies for the production of legume seeds in pure sowing and their mixtures with cereals. Habilitation dissertation). Rzeszów: Uniwersytet Rzeszowski.

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EKONOMICZNA EFEKTYWNOŚĆ PRODUKCJI MIESZAŃCOWEJ LINII GENETYCZNEJ PSZENŻYTA O RÓŻNYM POZIOMIE INTENSYWNOŚCI

Słowa kluczowe: pszenżyto ozime, odmiany, plon ziarna, nawożenie azotem, uprawa roli, efektywność, nadwyżka bezpośrednia

ABSRTAKT

Celem badań była ocena ekonomicznej efektywności produkcji mieszańcowej linii genetycznej pszenżyta ozimego w porównaniu z formą krótkosłomą, przy różnym poziomie intensywności w warunkach płodozmianu zbożowego. Obliczenia wykonano na podstawie trzyletnich (2017-2019) wyników badań polowych. W analizie uwzględniono sposoby uprawy roli (tradycyjna i uproszczona), zróżnicowane nawożenie azotem (0, 90 i 120 kg N/ha) i dwie form pszenżyta: krótkosłomą – odmiana Rotondo i mieszańcową linię genetyczną - BOH 2415. Za miarę efektywności ekonomicznej przyjęto nadwyżkę bezpośrednią. Efektywność ekonomiczną uprawy obu form pszenżyta ozimego oceniono z punktu widzenia wykorzystania jednego z podstawowych czynników produkcji, tj. ziemi. Obliczono także wskaźnik opłacalności brutto dla poszczególnych wariantów doświadczenia, jako relacja wartości produkcji do kosztów bezpośrednich. Z analizy wskaźników produkcyjno-ekonomicznych wynika, że korzystniejszym wariantem uprawy pszenżyta ozimego była technologia uprawy formy mieszańcowej z wykorzystaniem tradycyjnej uprawy roli (płużnej) i dawki nawożenia azotowego na poziomie 120 kg N/ha. Większy wpływ na poziom uzyskiwanej nadwyżki bezpośredniej wywierał poziom uzyskiwanych plonów i ceny skupu pszenżyta niż poziom ponoszonych kosztów bezpośrednich, zależnych od sposobu uprawy roli.

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