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ECONOMIC EFFICIENCY OF SPRING TRITICALE PRODUCTION WITH DIFFERENT LEVELS OF INTENSITY

Key words: spring triticale, varieties, grain yield, nitrogen fertilisation, tillage, efficiency, direct surplus

ABSTRACT. The aim of the study was to evaluate the economic efficiency of spring triticale varieties at different levels of production intensity. Three-year field results for the years 2017, 2018 and 2020 were used for the calculations. Factors such as tillage methods (conventional and reduced tillage), varying levels of nitrogen fertilisation (0, 70 and 100 kg N/ha) and varieties – Sopot and Milewo – were included in the analysis. Direct surplus was used as a measure of economic efficiency. The economic efficiency of spring triticale cultivation was assessed taking into account the use of one of the main production factors, i.e. land. For individual variants of the experiment, the gross profitability index was calculated as the ratio of production value to direct costs. The analysis of the production-economic indices showed that the technology with the use of traditional tillage (plough) and a nitrogen fertilisation rate of 70 kg N/ha were the more favourable variant for spring triticale cultivation. It was also found that the level of obtained direct surplus was more influenced by the level of obtained yields and purchase prices of triticale than by the level of direct costs incurred for tillage and sowing operations.

INTRODUCTION

Triticale is the youngest cereal species in cultivation. Thanks to its yield potential and good nutritive value, it is competitive with other cereal species [Djekic et al. 2011, Jaśkiewicz, Szczepanek 2018]. When analysing the economic importance of spring triticale, it is worth emphasising that it has lower soil requirements than spring wheat and spring barley. This is related to its greater tolerance to low soil pH, which favours the expansion of cultivation of this species.

One element of production technology is how the soil is cultivated. Changing the physical, chemical and biological properties of the soil optimises its productivity. Reduced

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tillage contributes to the accumulation of nutrients in the topsoil, which is important for plant growth and development [Smagacz 2012]. A study by Johan Arvidsson [2013] shows that reduced tillage compared to plough tillage results in a yield reduction of several per cent. In a study by Bogusława Jaśkiewicz and Alicja Sułek [2018], the tillage system did not unequivocally differ the yield of winter triticale. The analysis of production and economic indices [Jaśkiewicz et al. 2021] shows that the more favourable variant of winter triticale cultivation was the cultivation technology of the hybrid form using conventional (plough) tillage and a nitrogen fertilisation rate of 120 kg N/ha.

Mineral fertilisation, mainly with nitrogen, is another element of production technology [Jaśkiewicz 2021, Knapowski et al. 2009]. First and foremost, it contributes to yield growth. Determining optimum nitrogen fertilisation doses for triticale is difficult due to the non-uniform response of varieties [Jaśkiewicz 2021].

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

The aim of the study was to evaluate the economic efficiency of spring triticale varieties at different levels of intensity.

STUDY MATERIAL AND METHODOLOGY

The experiments were conducted at the Agricultural Experimental Station of IUNG-PIB in Osina in 2017, 2018 and 2020 within a 75% share of cereals in the sowing structure after spring wheat on soil classified as good wheat complex.

The first factor of the experiment was the tillage system, i.e. conventional (ploughing) and reduced tillage (no-till). In the plough tillage, a disc aggregate was used and pre-winter ploughing was carried out. This was followed by harrowing with a heavy harrow and a cultivation combination. In reduced tillage, the disc harrow was used twice, followed by active cultivation and sowing at a depth of 3-4 cm. In both cultivation systems, triticale grain was harvested with a combine with a straw shredder (Table 1).

In addition to the cropping system, nitrogen fertilisation rates, i.e. 0, 70, 100 kg/ha, were the differentiating factor in the experiments. 50% of the total nitrogen fertilisation rate was applied pre-sowing and another 50% at the stalk shooting stage (BBCH 30-31) in the form of ammonium nitrate (34%).

Table 1. Agronomic treatments according to tillage method

Conventional (plough) cultivation	Reduced tillage (no-till)
Disc cultivation (3 m), tractor NH110-90DT	
Pre-winter ploughing with 4-furrow rotary plough (1.6 m), NH TM150 tractor	Crop protection (12 m sprayer), Zetor 7011 tractor
Cultivation with heavy harrow (5.3 m), Zetor 7011 tractor	Disc cultivation (3 m), NH 110-90DT tractor
NPK fertilisation, spreader (12 m), Zetor 7011 tractor	
Cultivation with cultivator (2.8 m), Zetor 7011 tractor	Cultivation and sowing with Becker cultivator + Amazone seed drill (3 m), NH110-90DT tractor
Sowing, Amazone seed drill (3 m), etor 7011 tractor	
Crop protection (12 m sprayer), Zetor 7011 tractor	
N fertilisation (50%), spreader (12 m), Zetor 7011 tractor	
Harvesting with John Deere W540 combine harvester with forage harvester (5.5 m)	

Source: own elaboration

The third factor of the experiment was high-yielding spring triticale varieties. These include the Milewo variety (Strzelce Plant Breeding) entered in the National Variety Register in 2008 and the Sopot variety (Danko Plant Breeding) in 2015. The Milewo variety was characterised by an average plant height, while plants of the Sopot variety were lower. The area of the experimental plot for harvesting was 20 m^2. Sowing of spring triticale in 2017 and 2018 was performed in the third decade of March, and in 2020 in the first decade of April.

A sowing density of 4.5 million grains per ha was applied. Pre-sowing mineral fertilisation was applied in the form of superphosphate at a dose of 60 kg P/ha and potassium salt at a dose of 90 kg K/ha. Protective treatments against agrophages were applied after they exceeded the thresholds of economic harmfulness [Korbas, Mrówczyński 2011]. Protection of triticale against insecticides was limited to one spraying throughout the experiment. Herbicides were applied once under plough tillage and twice under reduced tillage, while fungicides were applied twice under plough tillage and three times under reduced tillage. One antifungicide spray was applied over the entire experimental area.

The production-economic evaluation was carried out in a simplified manner. Average grain yields for 2017, 2018 and 2020 were used as the main criteria for assessing production efficiency.

The calculation of direct costs took into account the actual inputs incurred according to the experimental instructions. All calculations were made per 1 ha. The tractive effort was determined on the basis of technological sheets maintained at Agricultural Experimental

Table 2. Consumption of seed, mineral fertilisers and plant protection products

<table>
<tr><th rowspan="2">Specification</th><th colspan="3">Varieties</th></tr>
<tr><th>Milewo</th><th colspan="2">Sopot</th></tr>
<tr><td>Seed rate (actual) [kg/ha]</td><td>205</td><td colspan="2">169</td></tr>
<tr><td colspan="4">Fertiliser application rate [kg/ha]</td></tr>
<tr><td>Potassium (potassium salt)</td><td colspan="3">90</td></tr>
<tr><td>Phosphorus (superphosphate)</td><td colspan="3">60</td></tr>
<tr><td>Nitrogenous (ammonium nitrate)</td><td>0</td><td>70</td><td>100</td></tr>
<tr><td>Soil cultivation method</td><td>Ploughshare</td><td colspan="2">Simplified</td></tr>
<tr><td>Herbicides</td><td>Mustang Forte 195 SE (0.8 l/ha)</td><td colspan="2">Vival 360 SL (5.0 l/ha)
Mustang Forte 195 SE (0.8 l/ha)</td></tr>
<tr><td>Fungicides</td><td>Input 460 EC (1.0 l/ha)
Delaro 325 EC (1.0 l/ha)</td><td colspan="2">Input 460 EC (1.0 l/ha)
Delaro 325 EC (1.0 l/ha)
Capallo 337.5 SE (1.7 l/ha)</td></tr>
<tr><td>Insecticides</td><td colspan="3">Decis Mega 50 EW (0.125 l/ha)</td></tr>
<tr><td>Anti-litter</td><td colspan="3">Moddus 250 EC (0.3 l/ha)</td></tr>
</table>

Source: own elaboration

Station of IUNG-PIB, taking into account cultivation activities and treatments according to the experimental instructions (Table 1 and 2).

The analysis also considered the effect of differentiated nitrogen fertilisation (0, 70 and 100 kg N/ha) and tillage methods (traditional and simplified) on the productive and economic efficiency of the cultivation technology of spring triticale varietys, by calculating fuel consumption costs according to the formula proposed by Adam Harasim [2006]. Fuel costs were calculated as the product of the tractor power expressed in kW, the coefficient determining fuel consumption per unit of power (0.110 g/kW) and the fuel price expressed in PLN per litre. The density of diesel was used to convert the amount of fuel from kilograms to litres (0.83 g/cm^3).

The production value of triticale grain per hectare and direct production costs were expressed in prices from the first half of 2022. A price of PLN 1,338 per 1 tonne was assumed for the crop and PLN 2,650 per 1 tonne of triticale for qualified, treated material. The price of 1 litre of diesel was assumed at PLN 6.8 per litre.

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

The economic efficiency of growing spring triticale varieties was assessed from the point of view of using one of the basic production factors: land (direct surplus in PLN/ha). The gross profitability index was also calculated for the individual variants of the experiment as the ratio of the production value (W) to the direct costs (K) (including the value of the fuel used).

FINDINGS AND DISCUSSION

The analysis of production and economic data showed that the most favourable variant of spring triticale cultivation was the technology with the Sopot variety, using traditional tillage (ploughing) and a nitrogen fertilisation dose at the average level – 70 kg N/ha (Table 3). The grain yield achieved in it (6.86 t/ha) was lower than the maximum by 0.09 t/ha, and thus the value of the harvested grain was lower (9,179 PLN/ha). This technology, due to the tillage method, requiring a higher number of crop harvests and thus higher fuel consumption, and the average level of nitrogen fertilisation (70 kg N/ha), was characterised by average direct costs of 2,939 PLN/ha. Therefore, in this variant, the highest value of direct surplus was obtained (6,239 PLN/ha, as well as the highest value of the profitability index – 312%.

Among the technologies with diversified mineral nitrogen fertilisation, the technology of spring triticale cultivation of the Milewo variety with the application of simplified soil cultivation and without nitrogen fertilisation turned out to be the least favourable variant. In that technology, the yield level of triticale was the lowest and amounted to 3.54 t/ha, and the value of obtained yield was 4,737 PLN/ha. Among the technologies analysed, it was distinguished by relatively low direct costs (2,696 PLN/ha), but the lowest value of direct surplus of 2,041 PLN/ha and the lowest profitability index – 176%.

For both spring triticale varieties analysed, similar relationships were observed between the experimental factors (tillage method and nitrogen fertilisation level) and the production and economic indices. Technologies with traditional (plough) tillage were characterised by higher yields, regardless of the level of applied mineral nitrogen fertilisation. Thus, they were characterised by a higher production value.

These technologies were also characterised by lower direct production costs (including the value of fuel consumed), regardless of the level of nitrogen fertilisation. Thus, the level of direct surplus obtained reached higher values in variants with plough cultivation, regardless of the level of nitrogen fertilisation. In a study by Bogusława Jaśkiewicz and Alicja Sułek [2018] conducted with triticale at different production intensities, the analysis of the value of direct surplus showed the advantage of technologies with a higher level of intensity over technologies with lower input use.

Table 3. Selected production-economic indices of spring triticale cultivation of Milewo and Sopot varieties at different levels of nitrogen fertilization and in different tillage systems

Specification	Variety Milewo						Variety Sopot					
	conventional (plough) cultivation			reduced tillage (no-till)			conventional (plough) cultivation			reduced tillage (no-till)		
	nitrogen fertilisation/nitrogen fertilisation [kg N/ha]											
	0	70	100	0	70	100	0	70	100	0	70	100
Grain yield [t/ha]	3.94	6.24	6.33	3.54	5.98	6.05	3.74	6.86	6.95	3.64	6.42	6.70
Value of grain harvested [PLN]	5,271.7	8,349.1	8,469.5	4,736.5	8,001.2	8,094.9	5,004.1	9,178.7	9,299.1	4,870.3	8,590.0	8,964.6
Direct costs [PLN], including:	2,336.4	3,034.7	3,320.6	2,695.8	3,394.1	3,680.0	2,241.0	2,939.3	3,225.2	2,600.4	3,298.7	3,584.6
– nitrogen fertilisation*	0.0	698.6	984.5	0.0	698.6	984.5	0.0	698.6	984.5	0.0	698.6	984.5
– tillage and sowing**	253.0			143.5			253.0			143.5		
Direct surplus [PLN]	2,935.3	5,314.4	5,148.9	2,040.7	4,607.1	4,414.9	2,763.1	6,239.4	6,073.9	2,269.9	5,291.2	5,380.0
Grain yield offsetting direct costs [t/ha]	1.75	2.27	2.48	2.01	2.54	2.75	1.67	2.20	2.41	1.94	2.47	2.68
Indicator of direct profitability without subsidies/Indicator of direct profitability without direct payment [%]	226	275	255	176	236	220	223	312	288	187	260	250

* Including application costs in the form of consumed fuel
** In the form of the cost of fuel consumed
Source: own elaboration

It was also observed that the value of selected production and economic indices (yield, production value, direct costs) increased with the increase in the level of nitrogen fertilisation, regardless of the spring triticale variety and the applied tillage method (Table 3). However, the value of direct surplus for the variant with maximum nitrogen fertilisation was the highest only in the variant with cultivation of the Sopot variety and application of simplified tillage. The increased costs of nitrogen fertilisation in this variant were compensated by a significant yield surplus (0.28 t/ha). In the remaining cases, the variant with fertilisation at the level of 70 kg N/ha proved to be the most effective.

In the conducted comparison of tillage and sowing methods for two spring triticale varietys, the value of the obtained direct surplus was more influenced by the level of triticale yield and, after taking into account high purchase prices, by the value of production, than by the costs of tillage and sowing treatments. The difference in production value between the traditional and simplified systems ranged from 134 PLN/ha to 589 PLN/ha (variety Sopot with 0 and 70 kg N/ha fertilisation, respectively). On the other hand, the impact of tillage and sowing treatments, expressed in terms of the cost of fuel consumed, on the level of direct surplus obtained, was in most cases much smaller. The difference in the value of the set of cultivation and sowing treatments between the analysed variants (irrespective of the level of fertilisation and the variety of triticale) amounted to 109 PLN/ha.

SUMMARY

The most favourable variant of spring triticale cultivation, in terms of the analysed economic indicators (direct surplus, profitability index), was the cultivation technology of the Sopot variety using conventional tillage (plough) and a nitrogen fertilisation rate of 70 kg N/ha.

In the economic analysis of the impact of the tillage method in spring triticale cultivation on the value of the direct surplus obtained, the level of yield obtained and the purchase price of triticale were more influential than the value of the direct costs incurred for tillage and sowing operations.

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EKONOMICZNA EFEKTYWNOŚĆ PRODUKCJI PSZENŻYTA JAREGO O RÓŻNYM POZIOMIE JEJ INTENSYWNOŚCI

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

ABSTRAKT

Celem badań była ocena ekonomicznej efektywności produkcji odmian pszenżyta jarego przy różnym poziomie intensywności produkcji. Do obliczeń wykorzystano trzyletnie wyniki badań polowych za lata 2017, 2018 i 2020. W analizie uwzględniono takie czynniki, jak: sposoby uprawy roli (tradycyjna i uproszczona), zróżnicowany poziom nawożenia azotem (0, 70 i 100 kg N/ha) oraz odmiany – Sopot i Milewo. Jako miarę efektywności ekonomicznej przyjęto nadwyżkę bezpośrednią. Efektywność ekonomiczną uprawy pszenżyta jarego oceniono, uwzględniając wykorzystanie jednego z głównych czynników produkcji, czyli ziemię. Dla poszczególnych wariantów doświadczenia obliczono wskaźnik opłacalności brutto, jako relację wartości produkcji do kosztów bezpośrednich. Z analizy wskaźników produkcyjno-ekonomicznych wynikało, że technologia z wykorzystaniem tradycyjnej uprawy roli (płużnej) oraz dawka nawożenia azotowego na poziomie 70 kg N/ha były korzystniejszym wariantem uprawy pszenżyta jarego. Stwierdzono także, że na poziom uzyskiwanej nadwyżki bezpośredniej większy wpływ miały poziom uzyskiwanych plonów i ceny skupu pszenżyta niż poziom ponoszonych kosztów bezpośrednich na zabiegi uprawy roli i siewu.

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