THE ECONOMIC ASSESMENT OF PRODUCTION TECHNOLOGY OF HARD WHEAT DEPENDING ON THE PRODUCTION INTENSITY LEVEL

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Abstract. The aim of the study was to assess the production and economic effects of spring wheat cultivar SMH87 depending on the intensity of production technology. The analysis was based on research conducted in 2013-2014 at the Experimental Station in Osiny belonging to the Institute of Soil Science and Plant Cultivation - State Research Institute in Pulawy. Wheat was grown using the following production technologies: medium-intensive and intensive. The studied technologies differed in the level of mineral fertilization and chemical plant protection against weeds, diseases, and pests. The studies showed a significant influence of the production technology intensity level on durum wheat yielding. Durum wheat cultivated under intensive technology yielded higher than under the average level of agrotechnics. However, a significant increase in grain yield was observed in the harvest year 2014, amounting to 1,07 t·ha⁻¹. The lowest direct costs were incurred with the use of medium-intensive technology, while the highest in intensive technology conditions. The difference in direct costs resulted primarily from the reduction of consumption of mineral fertilizers and reduction of plant protection treatments under the integrated technology compared to the intensive technology. The highest direct surplus from 1 ha of durum wheat cultivation was obtained with the use of intensive technology in 2014 (PLN 3696), which was 18.7 % higher than the average intensive technology. The profitability of durum wheat production in every technology was high. The most favourable direct profitability index was obtained by durum wheat cultivated according to medium-intensive technology.

Key words: durum wheat, production technology, economic assessment, yield.

JEL code: Q10, Q14

Introduction

Durum wheat (*Triticum durum*) is a species cultivated in regions with warm climates and low rainfall (Asia, Middle East, North America, Australia and Africa). Compared to common wheat, grains of durum wheat are characterized by vitreous, hard endosperm with a higher protein content, including gluten proteins, with a higher content of carotenoid dyes and a lighter and thinner fruit and seed coat (Rachon L., at all., 2015). Due to these properties, durum wheat grain reaches a high price and is a sought-after raw material on the international market, mainly for the production of pasta. Interest in durum wheat cultivation is growing not only in traditional regions, but mainly in countries where durum wheat had not been cultivated or had been marginally cultivated, e.g. Hungary, Germany or Poland (Rachon L., Szumilo G., 2002; 2006; Segit Z., Szwed-Urbas K., 2000). Due to the unique technological value of grain and its use in production, it is important to develop a production technology that would ensure its profitability. The profitability of cereal production is determined by grain purchase prices and the level of intensity of production technology, measured by direct costs, which reflect the consumption of means of production. One of the most important factors that determine the effectiveness of a given technology is mineral fertilisation, especially nitrogen fertilisation. This is the main factor influencing wheat yields. Among the factors differentiating the effectiveness of a given cereal production technology, one should mention the costs related to the protection of plants against weed infestation, diseases and insecticides (Jaczevska-Kalicka A., Krasinski, T., 2010). The ultimate goal of any technology to be used in practice is economic evaluation (Krasowicz S., Nowacki W., 2005). Only direct costs can be taken into account in the economic assessment, based on an incomplete, simplified calculation (Harasim A., 2007; Krasowicz S., 1999). The consequence of limiting the assessment to the direct costs is to calculate the direct surplus as the difference between the value of the grain harvested per hectare and the direct costs of the industrial means of production.

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The analysis was based on research conducted in 2013-2014 at the Experimental Station in Osiny belonging to the Institute of Soil Science and Plant Cultivation - State Research Institute in Pulawy. Spring wheat (*Triticum durum*) SMH87 cultivar was cultivated in a long-term experiment with the share of 75 % of cereals in crop rotation, using production technologies: medium-intensive and intensive. The studied technologies differed in terms of the level of mineral and chemical fertilization of plant protection against weeds, diseases, pests, and deforestation (Table 1). Wheat was cultivated on plots of 51 m². In the evaluation of economic efficiency, indicators were calculated for 1 ha.

Table 1

Characterization of the applied technologies for spring wheat

Specification	Technologies	
	Medium-intensive	Intensive
Previous crop	winter rape	
Fertilization (kg·ha⁻¹) N (ammonium nitrate)	50 (in spring before sowing) 40 (at BBCH 31) 10 (at BBCH 51)	60 (in spring before sowing) 60 (at BBCH 31) 35 (at BBCH 51)
P (superphosphate) K (potassium salt)	70 P ₂ O ₅ 105 K ₂ O	80 P ₂ O ₅ 120 K ₂ O
Herbicide	At BBCH 31: florasulan, aminopyralid 2.4 (0.8 l·ha ⁻¹)	At BBCH 31: florasulan, aminopyralid 2.4 (0.8 l·ha ⁻¹)
Fungicide	At BBCH 57: azoksystrobin (0.6 l·ha ⁻¹)	At BBCH 41: protiokonazol, spiroksamin (1.0 l·ha ⁻¹) BBCH 57: azoksystrobin + propikonazol cyprokonazol (0.6 l·ha ⁻¹ + 0.4 l·ha ⁻¹)
Growth regulator	-	At BBCH 31: trineksapak etylu (0.4 l·ha ⁻¹)
Insecticide	At BBCH 51: zeta- cypermetryn (0.1 l·ha ⁻¹)	At BBCH 51: zeta- cypermetryn (0.1 l·ha ⁻¹)

(Own study)

The amount of inputs was established on the basis of the actual use of fertilisers, seeds, and plant protection products in the experiment. The costs of means of production were determined on the basis of purchase prices, and the value of winter wheat production was determined according to the average grain purchase price in 2018 (IERiGZ-PIB, 2018). In grain production calculations, the sale price of PLN 1245 per 1 t of pasta wheat grain in the fourth quarter of 2018, was assumed. In order to evaluate the studied durum wheat production technologies, the Gross Margin category was used. The direct surplus from the activity (in this case of durum wheat cultivation) according to the methodology of the European Union (EU), is the annual production value obtained from 1 ha of cultivation, lowered by the direct costs incurred to generate this production (Nowak A., et al., 2013). The final stage of the economic calculation was the calculation of the direct profitability index as the ratio of production value to direct costs. For each technology, the size of production balancing the direct costs expressed in terms of grain necessary to cover these costs, was calculated. The analysis of profitability was incomplete as the category of direct surplus did not take into account indirect costs incurred during the production process.

Average air temperatures and total precipitation during the study period were prepared on the basis of data recorded at a meteorological station in Osiny. Meteorological conditions in 2013 and 2014 are shown in Figure 1.

Analyses of weather conditions in the wheat growing season, showed that 2013 was characterized by a lower amount of precipitation from April to July (327.4 mm) compared to 2014 (428 mm). Total precipitation was higher by 85 and 186 mm, respectively, as compared to the long-term average. The year of 2013 was exceptionally warm and moderately humid, while 2014 can be described as very wet with a moderate temperature from April to June. In this year, high air temperatures occurred in July during the ripening period of the grain.

(Own study)

Fig. 1. Meteorological conditions in 2013 and 2014 compared to the long-term average of 1981-2010

The aim of the study was to assess the production and economic effects of spring wheat cultivar SMH87 depending on the intensity of production technology.

The results were statistically analysed using a one-way ANOVA, using the Statgraphics Centurion XVI computer program. Significance of differences between means were evaluated using the Tukey test at the level of significance $p=0.05$.

Research results and discussion

Spring durum wheat was cultivated using two production technologies, differing in mineral fertilisation and the use of chemical plant protection agents. The range of differences between production technologies is presented in Tables 1 - 2. In direct costs, mineral fertilizers and plant protection products accounted for 60.0 % in medium-intensive technology, and 70.0 % in intensive technology (Table 3). The share of seed costs in the medium-intensive technology was 39.9 %, while in the intensive technology 30. %. Differences in the level of direct outlays determined the profitability of durum wheat production. Mineral fertilisation is the most energy-consuming and cost-consuming element of agro-technology and may exceed even 60 % of outlays incurred in cereal production (Dropka D., 2004). The influence of production technology intensity on spring wheat yield depended on the year of research (Table 2). In 2013 No significant influence on durum wheat yield was found. On the other hand, in 2014 durum wheat obtained a significantly higher yield level when cultivated under intensive technology. The increase in grain yield was $1.07 \text{ t} \cdot \text{ha}^{-1}$ in relation

to the yield obtained under medium-intensive technology. Rachon L., et al., (2014) and Panasiewicz K., et al., (2011). They also found that durum wheat responds with a significant increase in grain yield to a higher level of agrotechnology. Jarecki W., et al. (2013) obtained a higher level of durum wheat yield after the application of 150 t·ha⁻¹ in the uptake up to 90 N·ha⁻¹. Sulek A., Podolska G., (2012) showed that spring wheat cultivated according to intensive technology yielded 15.6 % higher in comparison to the integrated technology.

The effectiveness of mineral fertilization depended on the applied production technology. Wheat grain production per 1 kg of nitrogen applied in mineral fertilizers, was higher under medium-intensive than under intensive technology. Taking into account all fertiliser components, the differences between medium-intensive and intensive technology in terms of productivity of 1 kg NPK amounted to 8.2 % (Table 4).

The direct surplus, which is the difference between the value of grain yield and direct costs calculated for individual production technologies, showed significant differences. A comparison of the data in Table 4 shows that higher direct costs were incurred using intensive technology. The difference in direct costs resulted primarily from the reduction of mineral fertilizers and reduction of plant protection treatments in the medium-intensity technology compared to those applied in the intensive technology. The highest direct surplus from 1 ha of durum wheat cultivation was obtained in 2014 using intensive technology (3696 PLN). It was 18.8 % higher than the average intensive technology.

In 2013, the intensity of production technology did not differentiate this indicator. In other studies concerning winter wheat, a higher direct surplus from 1 ha of cultivation using intensive technology (PLN 3679) was found, which was 16.0 % higher than that obtained in the integrated technology and 8.8 % higher in the economical one (Sulek A., et al., 2016). On the other hand, the research by Nierobca P., et al., (2008) showed that the level of cereal yields was not proportional to the level of direct surplus. The highest direct surplus was obtained by these researchers with the use of medium-intensive and economical technology, and the lowest in the intensive technology conditions. An important measure of technology evaluation is the profitability of production, which is the relation of production value to direct costs. The profitability of spring wheat production in comparable technologies was high. In our research, the highest value of this indicator was achieved in medium-intensive technology (270 %) (Table 4). Szmigiel A., et al. (2006) also achieved the highest profitability of wheat production in low-cost technology without the use of chemical plant protection. Research conducted by Grabinski J., (2015) indicates that the profitability of the technology of lower intensity (with lower use of mineral fertilizers) was higher in relation to the technology obtained in intensive technology, despite similar wheat yields under both technologies.

Table 2

The cost of seeds, mineral fertilizers and plant protection agents (prices as at 2018)

Production technology	Seeds		Mineral fertilizers		Plant protection agents	
	PLN·ha ⁻¹	% of direct cost	PLN·ha ⁻¹	% of direct cost	PLN·ha ⁻¹	% of direct cost
Medium-intensive	770	39.9	936	48.5	221	11.5
Intensive	770	30.0	1275	49.7	521	20.3

(Oun study)

Table 3

Grain yields ($\text{t}\cdot\text{ha}^{-1}$) of durum wheat SMH87 depending on the production technology in 2013 and 2014.

Production technology	Years	
	2013	2014
Medium-intensive	4.18	3.96
Intensive	4.64	5.03
LSD _{0.05}	n.s.	0.825

n.s. – not significant differences
 (Own study)

Table 4

Yields and chosen and indicators of economic efficiency of durum wheat SMH87 production

Specification	Production technology			
	Years			
	2013		2014	
	Medium-intensive	Intensive	Medium-intensive	Intensive
Yield of grain [$\text{t}\cdot\text{ha}^{-1}$]	4.18	4.64	3.96	5.03
Productivity of N [$\text{kg grain}\cdot\text{kg}^{-1}\text{ N}$]	38.0	29.9	36.0	32.4
Productivity of NPK [$\text{kg grain}\cdot\text{kg}^{-1}\text{ NPK}$]	14.7	13.1	13.9	14.7
The value of production [$\text{PLN}\cdot\text{ha}^{-1}$]	5204	5776	4930	6262
Direct costs [$\text{PLN}\cdot\text{ha}^{-1}$]	1927	2566	1927	2566
Direct surplus without direct payment [$\text{PLN}\cdot\text{ha}^{-1}$]	3277	3210	3003	3696
Crop balancing direct costs [t]	1.58	2.06	1.55	2.06
Indicator of direct profitability without direct payment [%]	270	225	255	244

(Own study)

Conclusions

- 1) The intensity of the technology applied had an impact on the production and economic effects of spring durum wheat cultivation. Durum wheat cultivated under intensive technology yielded higher than under the average level of agrotechnics. A significant increase in grain yield was observed in the harvest year 2014, amounting to $1.07 \text{ t}\cdot\text{ha}^{-1}$.
- 2) The level of technology intensity of input costs determined the direct cost structure. Medium-intensive technology without growth retardant, with limited fungicide protection, and a low level of mineral fertilisation turned out to be cheaper.
- 3) Comparable technologies ensured profitability of durum wheat grain production. The most favourable profitability index was recorded for intensive technology in 2014.

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