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IMPACT OF NITROGEN FERTILISATION ON THE ECONOMIC EFFICIENCY OF WINTER WHEAT YIELD

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Abstract

The economic efficiency of winter wheat production with regard to nitrogen (N) fertilisation was studied on the results of experiment with the fertilisation of winter wheat variety Žitarka. In the experiment it was found out how different fertilisation treatments of N sidedressing (different total quantity, number of sidedressing and the target value at the first sidedressing) affect the yield quantity and the parameters of wheat quality. Economic analysis was used to establish the fact that different fertilisation treatments of wheat with N influenced significantly the economics of wheat production. Economically the most efficient sidederssing in the studied conditions was that with the total sidedressing up to 210 kg N/ ha – Nmin applied in three rates, and that with the target value of 120 kg N/ha at the first sidedressing.

Key words*: winter wheat, N fertilisation, grain quality, economic efficiency*

Introduction

The supply of winter wheat crop with nitrogen (N) during the growing period is one of the key factors influencing the economy of wheat production through the yield and grain quality obtained. Numerous authors (Tomasović, 1990; Leskošek, 1994a, b; Pechanek et al., 1997, Sušin and Zemljič, 2002, Garrido-Lestache et al., 2004) report on sidedressing of wheat with N which significantly affects the abundance of crop, the rapidity of growth, the size and number of ears and grains, and some indicators of yield quality (the content of crude protein, sedimentation value, test weight).

Winter wheat is sidedressed with N at three dates. While some authors (Tomasović, 1990, Pechanek et al., 1997) have found out that the third sidedressing does not contribute to a statistically significant increase of yield, Briški (1994) and Leskovšek (1994a, b) reported that it

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increases both the yield and the content of crude protein in grain. The previous experiments and researches carried out in Slovenia tried to find out optimum rates of N in three sidedressings and the relation between fertilising rates of N and grain quality.

Wheat protein content is influenced by environment, cultivar, N fertiliser rate, timing and method of N application, and the interactions between these factors. Farmers producing wheat face a challenge in making N fertilisation decisions because of the influence of fertilisation rates on yield and on protein concentration, and the influence of protein on wheat price. Protein is valued because it influences the suitability of the grain in making bread. The purchase price of wheat in the world and in Slovenia is determined with regard to quality parameters (table 1).

Table 1: Parameters of quality for wheat in Slovenia

	Quality classes		
	A	B	C
Crude protein (%)	14	12	10,3
Test weight (kg/100 l)	78	76	74
Falling number (FN)	280	250	220
Sedimentation	45	35	30

Source: Zemljič and Ileršič, 2008

Since both yield and protein affect profit, economically motivated growers will desire to apply N fertiliser at rates that maximize profit considering both yield and protein (Karuaihe in Young, 2005).

Only few studies investigated the crop quality response to applied N fertiliser and its economic consequences. Baker et al. (2004) determined profit-maximizing N fertiliser levels for hard red spring wheat for various wheat prices, N prices, and protein based price premium/ discount structures. An empirical model to examine economically optimal N fertiliser rates for winter wheat when N affects crop yield and crop price was presented by Gandorfer and Rajsic (2008).

Tanjšek and Tanjšek (2004) investigated the impact of mineral N fertilisation on the baking quality of wheat and on the intervention price. They found out that fertilisation with mineral N affected significantly the improvement of grain quality and the height of intervention price.

The purpose of our investigation was to establish the influence of N fertilisation through the yield and quality parameters (crude protein and sedimentation) on the economic efficiency of winter wheat produced by market producers.

Materials and methods

The current paper presents an economical evaluation of the results obtained in the experiment (Zemljič and Sušin, 2000) in which the influence of N fertilisation (KAN) on the yield and quality of winter wheat was studied. The experiment mentioned above was conducted in the regions of Prekmurje (the variety Žitarka) and Dolenjska (the variety Profit) in 1999. Among the quality parameters, crude protein and sedimentation value were analysed; those are two of the quality parameters (Zemljič and Ileršič, 2008)

influencing the classification of wheat yield in quality classes and, consequently, the height of purchase price for wheat. The classification of treatments into A, B and C quality classes (table 1) was carried out at a following presumption: if the wheat quality with regard to the two quality parameters, crude protein and sedimentation, was suitable for the classification in individual quality classes, the two parameters, falling number and test weight, are suitable, too.

Table 2: Yield and parameters of grain quality for wheat variety Žitarka

T	Yield (t/ha)	P (%)	SE	N (kg/ha)	Fertilisation dose (kg N/ha)			S	QC
	14 % moisture				1 spreading phase	2 stem elongation	3 ear emergence		
1	3,0	10,47	30	23 (Nmin)	-	-	-	0	C
2	4,7	10,69	30	80	80 - Nmin	-	-	1	C
3	5,8	10,76	30	120	120 - Nmin	-	-	1	C
4	5,9	11,19	41	160	160 - Nmin	-	-	1	C
5	6,8	12,55	43	170	120 - Nmin	50	-	2	B
6	6,5	13,10	42	210	160 - Nmin	50	-	2	B
7	7,0	14,16	50	210	120 - Nmin	50	40	3	A
8	6,0	13,29	45	170	80 - Nmin	50	40	3	B

** In the autumn the experiment was fertilised with 450 kg of NPK 7:20:30.*
Source: Zemljič and Sušin, 2000
T: Treatment; N: Total target value of N = Nmin (0-90 cm) at first sidedressing (23 kg N/ha) + fertilisation dose of N; SE: Sedimentation; P: Crude protein; S: Number of sidedressings
QC: Quality class

The costs of wheat production were evaluated as a model using the model calculations made by Agricultural Institute of Slovenia (AIS) with general basic positions and presumptions built in (Rednak, 1998, Splošna metodološka izhodišča …, 2010). The calculation for wheat was used as basic model (Zbirnik rastlinskih kalkulacij, Modelna kalkulacija za pšenico, 2010) which was modified and supplemented to meet the requirements of the research. After a preliminary short analysis of results obtained in the experiment we decided to present only the results for the variety Žitarka in the current paper. With regard to the results of fertilisation experiment (table 2) in individual treatments we varied the total target value N, the target value N at the first sidedressing, the number of sidedressings and quality class of yield. In the calculation we used the input prices valid for the 2010 yield from data bases at AIS. On revenue side we considered the purchase prices of wheat which were offered by purchasers after the harvest of summer 2010 (quality class A= 135 EUR/t, quality class B= 125 EUR/t and quality class C= 110 EUR/t) and budget support (regional payment for fields and repayment of excise duty) to which the wheat producers in Slovenia are entitled in 2010. Using model estimations we calculated the economic indicators with which we want to illustrate the economic efficiency of wheat production with regard to fertilisation with N.

Costs per product unit reduced by subsidies (LC):
LC (EUR/kg) = (MC + AM + DW + CC - SC - SUB)/ Y

MC (EUR/ha) = material and services bought (fertilisers, plant protection, seeds, hired machinery services, insurance, fuel, maintenance of machinery…);
AM (EUR/ha) = amortization (assets, machines) ;
DW (EUR/ha) = domestic work and obligations arising from work (net salary, contribution for health and pension insurance, taxes);
CC (EUR/ha) = capital costs;
SC (EUR/ha) = by-product = straw (costs of straw harvest);
SUB (EUR/ha) = subsidies (regional payment for fields and repayment of excise duty);
Y (kg/ha) = principal yield;

Revenue (R):
R (EUR/ha) = yield (kg/ha) * purchase price (EUR/kg) + SUB (EUR/ha)
Net value added (NVA): NVA (EUR/ha) = R – MC – AM
Net value added per hour of work invested (NVAH):
NVAH (EUR/h) = NVA/H
H = number hours of work invested

Results and discussion

The economic analysis of results obtained in the experiment has shown that the total target value of N, the number of sidedressings and the target value at the first sidedressing influence significantly the economic results of wheat production.

From the results presented in table 3 it is evident that the revenue (R) and net value added (NVA) per hectare are the highest in the treatment 7 while the production costs per unit of product reduced by subsidies (LC) are the lowest in the treatment 5. It turned out that similar to yield the economic results were the best at the fertilisation up to target value of 120 kg N/ha at the first sidedressing (treatments 7 and 5).

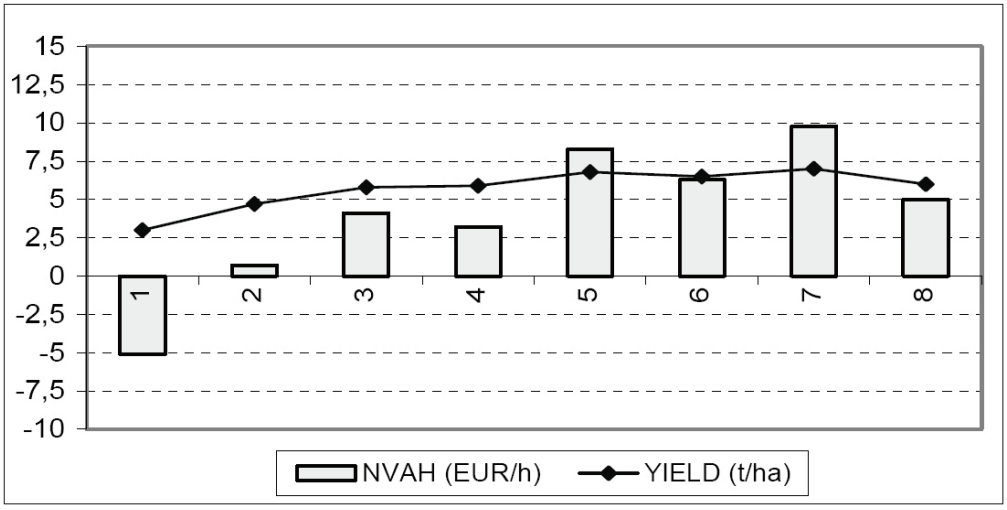
Table 3: Quantity and quality of yield and economic results for winter wheat production variety Žitarka, with regard to different fertilisation treatments

O	Yield (t/ha) 14 % moisture	N (kg/ha)	S	QC	LC (EUR/kg)	R (EUR/ha)	NVA (EUR/ha)	NVAH (EUR/kg)
1	3,0	23	0	C	0,230	800	-99	-5,1
2	4,7	80	1	C	0,172	1.052	17	0,7
3	5,8	120	1	C	0,147	1.223	109	4,1
4	5,9	160	1	C	0,151	1.233	84	3,2
5	6,8	170	2	B	0,141	1.465	250	8,3
6	6,5	210	2	B	0,151	1.425	188	6,3
7	7,0	210	3	A	0,145	1.570	306	9,8
8	6,0	170	3	B	0,160	1.340	149	5,0

The production costs per unit of product were the lowest at the treatment 5 when two sidedressings with the total target value of 170 kg N/ha-Nmin were applied while sidedressing up to the total target value of 210 kg N/ha-Nmin (treatment 7; third sidedressing during the earing added) have caused a certain increase of production costs (2 %). The yield has increased due to higher quantity of N added; however, the influence on the increase of yield was poorer than additional costs of the third sidedressing. On the other hand, additional sidedressing improved the grain quality (higher share of crude protein and better sedimentation) which was then classified in the quality class A. Revenue from selling the A quality class wheat (7.0 t/ha yield) was by 7 % higher than that from selling the B quality class (6.8 t/ha), which had an impact on better production economy in the case of additional third sidedressing (+ 40 kg N/ha).

The results have also shown that a too small N dose at the first sidedressing (80-Nmin) negatively influences the yield size, which can not be compensated by the second and the third sidedressing (comparison between the treatment 5 and 8).

Figure 1: Impact of different fertilisation treatments on yield and net value added for winter wheat production variety Žitarka



Additional third sidedressing (treatment 8) improved the grain quality to a certain degree, but in spite of that it did not reach the quality of the class A. Due to additional third sidedressing the costs of wheat production were higher, which, beside the lower yield, had an additional effect on poorer economic results in the treatment 8 (by 40 % lower income per one hour of invested work than in the treatment 5). In case of a too low chosen target value of N at the first sidedressing (80-Nmin), additional third sidedressing has proved as uneconomical as it had increased the production costs additionally (+13 %) and did not contribute to a sufficient increase of quality parameters.

A too large dose of N at the first sidedressing (160-Nmin) also negatively influences the height of yield (higher risk of lodging). From the comparison of

treatments 6 (160-Nmin) and 5 (120-Nmin) it is evident that in spite of the 40 kg higher quantity of the total N added in the treatment 6, the wheat yield was lower than in the treatment 5, and the grain quality was similar and suited the quality class B. Due to higher quantity of N added the wheat production costs in treatment 6 were by 7 % higher than in treatment 5 while the income per one hour of invested work in the case of a too high chosen target value at the first sidedressing was by one quarter lower than at a properly chosen target value (120 kg N/ha-Nmin) and lower total quantity of N added (treatment 5).

On the other hand, the comparison of the effect of wheat fertilisation (treatments 6 and 7) with the same total target value of N (210 kg N/ha), but different target values at the first sidedressing and different number of sidedressings, indicates that at a properly chosen target value at the first sidedressing (120-Nmin) and three sidedressings, the yield was higher by 500 kg/ha, the quality was better (quality class A), and the economy of wheat production improved significantly as well.

Conclusions

The economic analysis of the results obtained in the experiment with N sidedressing of wheat has shown that the total target value of N, the number of sidedressings and the target value of N at the first sidedressing significantly affect the economic results of wheat production. Increasing the total target value of N improves the economy of wheat production (treatments 1, 2, 3 and 7), since the income per hectare and the income per one hour of invested work increase, too. Beside by the total target value of N, the economy of production is also significantly influenced by target value at the first sidedressing. First sidedressing to target value 160 kg/ha may have an effect on the poorer economic efficiency of wheat production (treatment 4 and 6), since additional quantity of N at the first sideressing does not affect the increase of yield quantity and quality to an extent to be able to cover additional production costs by the value of yield. A too low target value at the first sidedressing (treatment 8) in the studied conditions did not suffice to reach the maximum yields. Also, the introduction of the third sidedressing did not improve the grain quality to an extent (same quality class) to cover a bit lower yield and additional costs of the third sidedressing. In the current experiment with the variety Žitarka sidedessing up to the total target value of 210 kg N/ha -Nmin carried out in three rates and the target value of 120 kg N/ha at the first sidedressing has proved as economically the most well-founded. In order to reach maximum economic efficiency in wheat production it is therefore very important to know the technological requirements of individual varieties which ensure reaching optimum yields of a proper quality.

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