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EFFECT OF DIFFERENT LEVEL OF NITROGEN FERTILIZER ON GRAIN YIELD OF WHEAT IN CENTRAL PART OF OLTENIA

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Abstract

Nitrogen is an important nutrient that plays a significant role in maximizing crop yields worldwide. Optimizing nitrogen fertilization ensures suitable grain yields and reduces environmental pollution. The aim of the research was to investigate the effect of different nitrogen levels on grain yield of wheat and nitrogen use efficiency. The field research was performed at Agricultural Research and Development Station Șimnic on a reddish preluvosoil, during three consecutive growing seasons. Five nitrogen levels: 0 (control), 30, 60, 90 and 120 kg N/ha were used. Statistical analysis showed that nitrogen levels had a significant effect on grain yield in all years of study. On average, the three-year data indicated that nitrogen fertilizers generated increases of 30-114%, representing 7.8-29.2 q/ha compared to the control. The highest agronomic efficiency of nitrogen (33.7 kg/kg) was at a level of 60 kg N/ha, which is considered a rational application in terms of nitrogen emissions to the environment.

Key words**:** agronomic efficiency; fertilization; nitrogen; *Triticum aestivum*

INTRODUCTION

Wheat (*Triticum aestivum* L.) is an important cereal globally that plays an important role in food security, being cultivated on 214 million hectares [9].
Nitrogen is an important fertilizer used intensively in field crops to maximizing the grain yield and quality.
In 2019, the quantity of N fertilizer used in agriculture worldwide was about 118.2 million tons. The increased use of these fertilizers has led to a rapid rise in prices, being a significant concern for farmers [13].
At a high fertilization rate, nitrogen can remain in the soil, being absorbed by the following crops or can lead to environmental pollution such as nitrate leaching and greenhouse gas emission [25].
Agronomic response to the use of fertilizer is a strategy that helps to avoid excessive application and economic losses [14].
Low nitrogen use efficiency at a high N input threatens the sustainability of agro-ecosystems [26].
Many studies showed that the nitrogen use efficiency can be increased through good management practices and crop breeding.
Usually, the values of agronomic efficiency for cereals crops vary between 10 and 30 kg/kg N.
The values above 30 kg/kg N can be found in well-organized growth systems or low levels of soil nitrogen [8, 16].
Previous researches indicated that climatic conditions and soil types are environmental factors that have significant impacts on yield of wheat [2, 11, 22].
The central part of Oltenia is often affected by drought and heat, with only two out of ten years being favourable to crops [4, 5, 6, 18, 23].
The optimization of nitrogen fertilizers is considered to be a primary means of increasing grain yield, in improving use efficiency [3].
The aim of this study was to investigate the grain yield and the agronomic nitrogen efficiency of wheat cultivated under agro-climatic conditions of central part of Oltenia.

MATERIALS AND METHODS

This study was conducted at the Agricultural Research and Development Station Șimnic - Craiova under rain-fed conditions for three consecutive growing season (2015/16, 2016/17 and 2017/18), in the long-term crop rotation after pea (pea-wheat-maize-wheat-sunflower). The variety Dropia was the test variety in all growing seasons.

The field trial was laid out under randomized block design with three replications on a reddish preluvosoil, which is characterized by a humus content of 2.2-2.7%, poorly supplied with nitrogen (0.071-0.072 mg/kg), well supplied in phosphorus (32.2-52.2 mg/kg) and medium supplied in potassium (104-125 mg/kg) and a pH = 5.08-5.33 [17].

Five different levels of nitrogen i.e. 0 (control), 30, 60, 90, 120 kg N/ha were assessed.

Nitrogen fertilization (in the form of NH_4NO_3) was done before sowing and in early spring.

All the agronomic practices were carried out similar for all plots.

Agronomic efficiency (AE) was calculated according to [3]:

$$AE\ (kg/kg)\ =\ \frac{Gf - Gu}{Na}$$

where Gf = grain yield in the fertilized plot (kg);

Gu = grain yield in the unfertilized plot (kg) ;

Na = the quantity of nitrogen applied (kg).

The data were analyzed statistically using ANOVA, and LSD test was applied at 5%, 1% and 0.1% probability level to compare variant averages.

Pearson’s correlation coeffcient and linear regrresion were used to assess the relationships among N levels and grain yield.

The amount and distribution of precipitation and average air temperature, varied significantly across the three growing seasons (Tables 1 and 2).

In terms of precipitations, for the first growing season (2015/16) and for the third season (2017/18), the sum of precipitation was extremely high, above to multiannual average (+232.0 mm, +340.3 mm, respectively), having negative influence on grain yield. For the second season (2016/17) it was lower, below the multiannual average (-81.7 mm).

The average air temperature was above to multiannual average in all growing seasons (+1.8°C, +0.6°C and + 1.4°C, respectively).

Table 1. Monthly precipitation in 2015/16, 2016/17 and 2017/18

Months	2015/16	2016/17	2017/18	Multiannual average
October	70.3	63.3	100.2	44.5
November	11.5	75.2	70.3	44.9
December	0	5.0	62.0	45.1
January	66.2	11.1	36.3	32.7
February	37.3	31.2	72.5	30.6
March	127.2	32.1	95.0	33.7
April	48.1	71.1	11.1	46.0
May	101.2	74.2	60.2	66.9
June	121.3	0	182.3	67.9
July	44.1	89.2	177.3	61.5
August	26.0	5.0	19.2	48.9
September	40.2	26.0	19.0	42.4
Sum	797.1	483.4	905.4	565.1

Source: Own processing based on data from Meteorological Station Șimnic, Craiova.

Table 2. Monthly average air temperature in 2015/16, 2016/17 and 2017/18

Months	2015/16	2016/17	2017/18	Multiannual average
October	11.0	10.3	12.7	11.8
November	8.9	5.2	6.4	5.5
December	4.7	-0.3	3.2	0.4
January	-2.5	-5.1	1.4	-1.4
February	7.5	1.6	0.8	1.0
March	7.7	9.8	3.9	5.6
April	14.7	11.1	16.6	11.8
May	16.3	16.7	19.2	16.9
June	21.9	23.4	21.6	20.4
July	23.9	24.2	22.3	22.6
August	23.1	25.4	24.1	22.1
September	19.5	19.4	19.2	17.5
Average	13.0	11.8	12.6	11.2

Source: Own processing based on data from Meteorological Station Şimnic, Craiova.

RESULTS AND DISCUSSIONS

Grain yield

According to ANOVA results, grain yield was significantly affected by increasing nitrogen fertilization in all growing seasons. The contribution of nitrogen on wheat yield is remarkable (Table 3).

The first (2015/16) and third (2017/18) growing seasons were extremely hot and rainy, therefore the yields were lower per fertilization variant compared to 2016/17 season.

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Excessive precipitations cause the problem of water logging, reducing the availability of nitrogen [2, 3].

Similarly, low rainfall restrict root growth and reduce N availability and uptake [10].

In all growing season, the highest grain yields were recorded at the highest nitrogen level (120 kg N/ha).

On average, over three seasons, increase of nitrogen level from 0 to 30, 60, 90 and 120 kg N/ha increased grain yield by 7.8, 20.2, 25.7 and 29.2 q/ha, respectively, or by 30%, 79%, 100% and 114%, respectively (Figure 1).

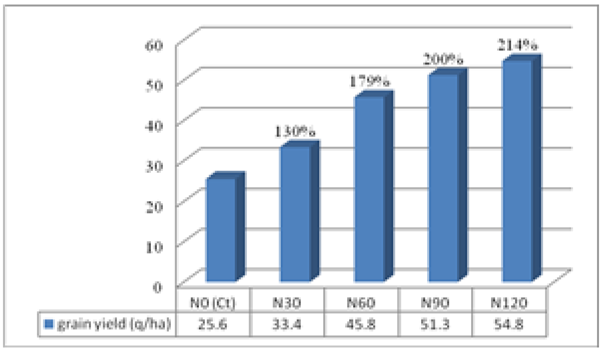

Fig. 1. Effect of nitrogen fertilization on grain yield (three-year average)
Source: Own calculation.

Trend of regression changes of grain yield for different levels of nitrogen is presented in Figure 2.

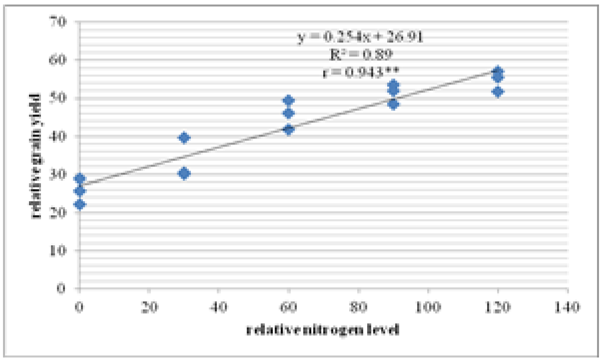

Fig. 2. Trend of regression changes in grain yields with different nitrogen levels
Source: Own calculation.

Grain yield of wheat had a linear and positive significant relationship (p = 0.01) with different levels of nitrogen.

Coefficient of correlation was r = 0.943 and coefficient of determination was R^2 = 0.89 which revealed that the variation in levels of nitrogen explained about 89% of the variation of grain yield.

Many studies showed similar results for variation in grain yield due to level of nitrogen and climatic conditions [2, 15, 19, 21, 24].

Agronomic efficiency

The agronomic efficiency of nitrogen is a valuable indicator of optimizing of N supply.

In our study, differences in agronomic efficiency were observed due to the variation in N level and due to climatic conditions from growing seasons (Figure 3).

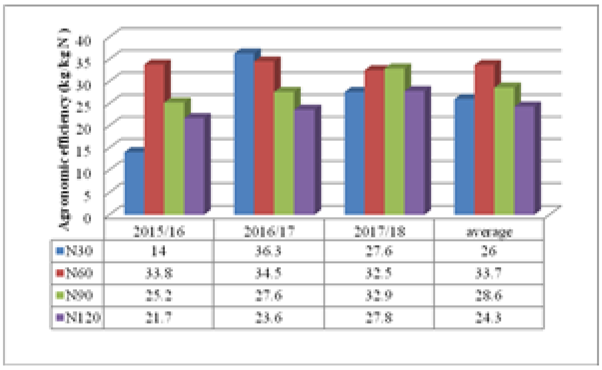

Fig. 3. Effect of nitrogen fertilization on use efficiency (Agronomic efficiency)
Source: Own calculation.

In 2015/16, the values of nitrogen agronomic efficiency ranged from 14 kg/kg in variant of 30 kg N/ha to 33.8 kg/kg in variant of 60 kg N/ha. Thus, the nitrogen use efficiency increased in response to application N up to 60 kg N/ha, but decreased progressively as the level increased.

In 2016/17, the agronomic efficiency values ranged from 23.6 kg/kg in variant with 120 kg N/ha to 36.3 kg/kg in variant with 30 kg N/ha. However, efficiency declined when N level was raised from 60 to 120 kg N/ha.

In 2017/18, the values of agronomic efficiency ranged from 27.6 kg/kg in variant with 30 kg N/ha to 32.9 kg/kg in variant with 90 kg N/ha. Thus, increases in agronomic efficiency were observed only up to 90 kg N/ha.

[2 and 22] also showed that the values of agronomic efficiency in a year with excessive rainfall were lower than the values of the year with less rainfall.

On average, agronomic efficiency increased to application N level up to 60 kg N/ha, but decreased when N level was raised from 90 to 120 kg N/ha.

Table 3. Effect of nitrogen fertilization on grain yield of wheat

Variant	Grain yield (q/ha)	Difference (q/ha) ±	% to N_0 (control)	Significance
2015/16				
N_0 (control - Ct)	25.8	Ct	100	-
N_{30}	30.0	4.2	116	*
N_{60}	46.1	20.3	179	***
N_{90}	48.5	22.7	188	***
N_{120}	51.8	26.0	201	***
LSD 5% = 4.2; LSD 1% = 5.5; LSD 0.1% = 7.2				
2016/17				
N_0 (control - Ct)	28.8	Ct	100	-
N_{30}	39.7	10.9	138	***
N_{60}	49.5	20.7	172	***
N_{90}	53.6	24.8	186	***
N_{120}	57.1	28.3	198	***
LSD 5% = 1.9; LSD 1% = 2.5; LSD 0.1% =3.3				
2017/18				
N_0 (control - Ct)	22.2	Ct	100	-
N_{30}	30.5	8.3	137	***
N_{60}	41.7	19.5	188	***
N_{90}	51.8	29.6	233	***
N_{120}	55.5	33.3	250	***
LSD 5% = 2.4; LSD 1% = 3.3; LSD 0.1% = 4.2				

Source: Own calculation.

These results suggest that, under rainfed conditions from the central part of Oltenia, wheat crops should not be fertilized to levels higher than N_{60}.

This supports findings of other authors [15] and [20], who reported that variation in climatic conditions between the different growing seasons is a major limiting factor for optimal nitrogen fertilizer application in wheat production.

A decreasing trend in agronomic efficiency of wheat with increasing nitrogen levels also was reported by other researchers [1, 7, 12].

Also, the type of soil is a factor that limits the availability of nitrogen applied as fertilizer to wheat crop.

[22] reported that under the level of nitrogen 60 kg/ha was obtained the maximum agronomic efficiency of 32.7 kg/kg under soil conditions of Luvic Chernozem.

In contrary, [11 and 24] reported that the best agronomic efficiency was obtained at the rate of 100 - 120 kg N/ha in Dyschrochrept soil (according to USDA Taxonomy) and at the rate of 100 kg N/ha in Pseudogley soil (Stagnosol), respectively.

CONCLUSIONS

The results of this study (obtained during three growing seasons) indicated that wheat yield and agronomic efficiency of nitrogen depends greatly on both the level of nitrogen fertilization and the growing season (climatic conditions).

The application of nitrogen level of 120 kg/ha improved grain yield (up to 114%) in comparison to control variant, but had a detrimental effect on agronomic efficiency.

The best agronomic efficiency of nitrogen (33.7 kg/kg) was at a level of 60 kg N/ha. Thus, the application of nitrogen at this level is considered a rational application in terms of obtaining an optimum yield of wheat and nitrogen emissions to the environment in the study area.

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