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EFFECTS OF DIFFERENT NITROGEN RATES AND FERTILIZERS ON MAIZE YIELD UNDER GROWING CONDITIONS OF SOUTH ROMANIA

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Abstract

The actual increasing concerns of our society about the adverse environmental impacts of nitrogen losses in the context of increasing cost of nitrogen fertilizers impose to the farmers the optimization of nitrogen fertilization according to specific growing conditions of their crops. Nowadays, the selection of the right fertilizer products, the appropriate rate and time of application are essential for farmers to make sound nitrogen management decisions. In this context, the aim of this paper is to present the obtained results regarding the effects of different nitrogen rates and nitrogen fertilizer products on maize grain yield under the specific growing conditions of South Romania. The research was carried out in field experiments located in South Romania (44º22' N latitude and 26º89' E longitude), under rainfed conditions in the years 2022 and 2023. The experimental factors were the following: Factor A – Nitrogen Rate, with 4 graduations, respectively 36 kg/ha, 80 kg/ha, 120 kg/ha, 160 kg/ha; Factor B – Nitrogen Fertilizer, with 4 graduations, respectively Ammonium Nitrate, Urea, Urea with NutriSphere-N, Urea Ammonium Nitrate (UAN). The obtained results brought attention to the positive effects of Urea with NutriSphere-N to the maize grain yield, as well as to the dependence of the nitrogen rate on the climatic conditions of the year. Under drought conditions, the nitrogen rate should not be high, as this could be even a limiting yielding factor.

Key words*: maize, nitrogen, rate, fertilizer, grain yield.*

INTRODUCTION

Maize (*Zea mays* L.) has a special importance at global level, this being given by its food and fodder values, by the several uses as raw material in various industrial sectors, as well as by the agronomic characteristics of the crop, such as: high ecological plasticity, high yielding potential, very good capacity to capitalize on fertilizers and irrigation water, full mechanization of the crop technology, high multiplication coefficient, small amounts of seed required for sowing, and it does not impose special restrictions in the crop rotation. Also, grain maize is an important cash crop for farms without livestock (Finke et al., 1999). Maize's ecological flexibility makes it "the plant of choice" for grain and feed in climates raging from temperate to tropical as long as there is no frost and mean temperatures are mostly above 10 degrees Celsius (Haraga & Ion, 2022). Therefore, maize is cultivated in many regions of the world (Erenstein et al., 2013).

As harvested area, maize ranks the second place in the world, after wheat, and the first place in Romania, which has the largest cultivated area with grain maize in the European Union.

Fertilizers are essential for providing the necessary nutrients to the soil and promoting plant growth, their efficient use being important to ensure that plants get the right amount of nutrients they need to produce a high yield (Zaib et al., 2023). Improving the nutritional status of plants through fertilizer application and maintaining soil fertility has been the critical step in food production since the beginning of the "Green Revolution" in both developed and developing countries (Huang et al., 2021).

Evaluation of long term field studies has shown that fertilizer input is critical to crop production, the average percentage of yield attributable to fertilizer generally ranging from about 40 to 60% in temperate climates and tends to be much higher in the tropics (Stewart & Roberts, 2012). Practically, in the modern agriculture, the importance of using chemical fertilizers is undeniable (Leonte et al., 2023).

Mineral nutrients are essential for increasing maize yields, maintaining soil productivity, and

preventing soil degradation. Among nutrients, nitrogen (N) is a major one, this being needed in large amount to increase growth and yield of maize (EL-Guibali et al., 2015).

Maize is known to be a heavy feeder of nitrogen fertilizer (Muhamman et al., 2014). Nitrogen fertilizer is universally accepted as a key component to high maize grain yield and optimum economic return (Gehl et al., 2005).

Nitrogen is a very critical nutrient for maize production, but in the same time it is also the most difficult to manage. Optimization of nitrogen fertilization in maize crop cannot be done on a global scale, but must be done for specific soil and climatic conditions, in accordance with other agrotechnical activities (Matev & Minev, 2020).

In many situations, profitable maize production requires supplemental nitrogen, but sometimes the narrow profit margins impose to closely manage the costs. Excess nitrogen application, more than maize plants can use results in nitrogen loss to the environment, generating pollution problems and loss of money. Therefore, the selection of the right fertilizer products, the appropriate rate and time of application are essential for farmers to make sound nitrogen management decisions.

One of the important factors, which influence the yields of agricultural crops, is the weather condition (Pirttioja et al., 2015). It should be noted that not only crop yields (Ray et al., 2015), but also the efficiency of the use of resources, in particular nutrients from soil and fertilizers (Ryan et al., 2012) are influenced by the weather conditions. Several studies have evaluated the behavior of maize genotypes in various climatic conditions (Ramirez-Cabral et al., 2017) all over the world, and the results shows that crop yields were greatly influenced by the weather conditions of the year.

Drought is one of the main constraints in maize cultivation in South Romania, which is the most important Romanian growing area for maize (Ion et al., 2023). In the context of evident climate changes in the maize growing areas from South Romania, the farmers need to adapt and find the best solutions regarding the nitrogen fertilization. In this context, the aim of this paper is to present the obtained results regarding the effects of different nitrogen rates and nitrogen fertilizer products on maize grain yield under the specific growing conditions of South Romania.

MATERIALS AND METHODS

The research was carried out in field experiments located in South Romania, respectively at Agribest Mânăstirea Farm (44º22' N latitude and 26º89' E longitude) in the area of Mânăstirea commune, Călărași county. The field experiments were performed under rainfed conditions in the years 2022 and 2023.

In the studied area, the specific soil is chernozem cambic with a humus content of 3.29% and a pH varying from 6.4.

For the period March-September 2022, the average temperature was 17.8ºC, respectively 18.6ºC for 2023. For the same period (March - September), the sum of rainfall was 281.7 mm in 2022 and 238.4 mm in 2023 (Table 1). In both years, the months March, July and August were dry months. The highest rainfall was registered in April, June and September in 2022 and in May and June in 2023. As a conclusion, the year 2023 can be characterized as being warmer and drier than the year 2022.

The studied biological material was the maize hybrid KWS Kashmir from FAO group 370, which is a simple hybrid designed for intensive production with a fast release of moisture in the final stage of grain ripening. The kerner is quite large, having a high TGW (Thousand Grain Weight) value, which is one of the key elements of a high yield.

The preceding crop was winter wheat in both experimental years. Also, the crop technology was similar in both years. After harvesting the preceding crop, there was performed a harrowing work, and in Autumn (October) there was performed the ploughing at 25 cm depth. The preparation of the germination bed was made with a combinatory one day before sowing. The sowing was done in the first decade of April, with a sowing density of 70,000 germinal seeds/ha, at a depth of 7 cm and at 70 cm row spacing. The control of the weeds was performed by the application immediately after sowing of the herbicide Adengo (Isoxaflutole 225 g/l + Thiencarbazone-methyl 90 g/l + Cyprosulfamide (safener) 150 g/l), in a rate of 0.35 l/ha.

The field experiments were based on the method of subdivided plots into 3 replications, with the following factors:

- Factor A – Nitrogen Rate, with 4 graduations:
  - a1 - 36 kg/ha;
  - a2 - 80 kg/ha;
  - a3 - 120 kg/ha;
  - a4 - 160 kg/ha.
- Factor B – Nitrogen Fertilizer, with 4 graduations:
  - b1 - Ammonium Nitrate;
  - b2 - Urea;
  - b3 - Urea with NutriSphere-N;
  - b4 - Urea Ammonium Nitrate (UAN).

Ammonium Nitrate (NH_4NO_3) is a nitrogen fertilizer containing 50% NH_4^+ (the ammonium ion) and 50% NO_3^- (the nitrate ion), with a total nitrogen content of 33.5%.

Urea [$CO(NH_2)_2$] is an organic nitrogen fertilizer containing 46% nitrogen.

Urea with NutriSphere-N is a urea fertilizer coated with Maleic Itaconic Copolymer (Nutrisphere-N) designed to enhanced efficiency fertilizer product through reducing of urea volatilization, nitrification, and denitrification processes.

Urea Ammonium Nitrate (UAN) is a liquid fertilizer that contains a mixture of urea and ammonium nitrate, with a nitrogen content of 32%.

At sowing, there was used Diammonium Phosphate (DAP) 18:46:0 in a rate of 200 kg/ha of commercial product, which assured 36 kg/ha of nitrogen and 92 kg/ha of phosphorus. The difference of nitrogen for each rate and fertilizer product was applied before seedbed preparation. The experimental variant with 36 kg/ha of nitrogen, which was chosen as control variant, received only the nitrogen coming from the DAP fertilizer used on all the surface.

Each experimental variant consisted of 126 m^2 resulting from 18 plant rows at 70 cm row spacing, which means 12.6 m, and 10 m of row length.

The grain yield was calculated in kg/ha and it was reported at 14% moisture content.

Table 1. Climatic conditions during maize plant's vegetative period at Mânăstirea, Călărași county, Romania

Month	Temperature (ºC)		Rainfall (mm)	
	2022	2023	2022	2023
March	3.7	8.3	15.8	7
April	11.9	10.8	68.8	25.6
May	17.7	16.2	31.9	97
June	22.3	21.6	69.2	52.8
July	25.1	25.9	17.3	14.2
August	25.1	25.7	13.5	30.7
September	18.6	21.4	65.2	11.1
Average/Sum	***17.8***	***18.6***	***281.7***	***238.4***

RESULTS AND DISCUSSIONS

The grain yields obtained at maize under specific conditions of South Romania with a nitrogen rate of 36 kg/ha in the control variant are quite high despite the small amount of received nitrogen, respectively 7,616 kg/ha in 2022 and 4,496 in 2023 (Table 2). This is due to the soil good fertility, the most important limiting factor being the climatic conditions, firstly the rainfall and then the high temperatures especially in the flowering period. Thus, the yield obtained in 2023 is much lower than that obtained in 2022, the year 2023 being warmer and drier than the year 2022.

Fertilization with nitrogen no matter the rate, fertilizer product and climatic conditions of the year determined obtaining of differences assured statistically, except the application of ammonium nitrate at highest rate (160 kg/ha of nitrogen) in the year 2023 (Table 2).

The highest grain yields were obtained in both experimental years in the condition of using Urea with NutriSphere-N as fertilizer product at the highest rate, respectively at 160 kg/ha of nitrogen, respectively 11,231 kg/ha in 2022 and 5,305 kg/ha in 2023.

By applying nitrogen fertilizers at different rates, the smallest yield increase compared to the yield obtained in the control variant

(36 kg/ha on nitrogen) was obtained in the condition of using Urea at the rate of 80 kg/ha of nitrogen in 2022 (1508 kg/ha yield increase), and in the condition of using Ammonium Nitrate at the rate of 160 kg/ha of nitrogen in 2023 (276 kg/ha yield increase).

In 2022, at the nitrogen rate of 80 kg/ha, the highest grain yield was obtained in the conditions of using UAN, which being liquid is fast used by the maize plants, while at the rates of 120 and 160 kg/ha the highest grain yields were obtained in the conditions of using Urea with NutriSphere-N. In the same year, the smallest grain yield was obtained in the conditions of using Urea at the nitrogen rate of 80 kg/ha, and in the conditions of using Ammonium Nitrate at the rates of 120 and 160 kg/ha.

In 2023, respectively in the conditions of higher temperatures and lower rainfall than in 2022, the highest grain yields were obtained in the conditions of using Urea with NutriSphere-N at the rates of 80 and 160 kg/ha of nitrogen, and in the condition of using Urea at the nitrogen rate of 120 kg/ha. In the same year, the smallest grain yield was obtained in the conditions of using Ammonium Nitrate at the nitrogen rates of 80 and 160 kg/ha, and in the conditions of using UAN at the rate of 120 kg/ha.

As average values obtained at different nitrogen rates, in both experimental years the differences obtained by applying nitrogen compered to control variant were assured statistically (Table 3). But, if in 2022 the difference was just positive distinct significant at the nitrogen rate of 80 kg/ha and positive very significant at the nitrogen rates of 120 and 160 kg/ha, in 2023 the difference was positive very significant at the nitrogen rates of 80 and 120 kg/ha, and just positive distinct significant at the nitrogen rate of 160 kg/ha.

The highest average grain yield was obtained at the nitrogen rate of 160 kg/ha in 2022 and at the nitrogen rate of 120 kg/ha in 2023 (Table 3). In has to be highlighted that in the warm and dry year 2023, the average grain yield obtained at the nitrogen rate of 160 kg/ha is smaller than that one obtained at the nitrogen rate of 80 kg/ha. Moreover, even the highest average grain yield was obtained at the nitrogen rate of 120 kg/ha, the yield difference between that one and that obtained at the nitrogen rate of 80 kg/ha is very small, respectively of 59 kg/ha.

As average values obtained at different nitrogen fertilizers, in both experimental years the differences obtained compared to control Ammonium Nitrate fertilizer are not statistically significant (Table 4). The highest average grain yields in both experimental years were registered in the case of fertilizer Urea with NutriSphere-N. On the second place comes the fertilizer UAN, on the third place the fertilizer Urea, and on the last place is Ammonium Nitrate.

Table 2. Maize grain yields at different nitrogen rates and nitrogen fertilizers under different climatic conditions in South Romania

Experimental factors		Yields obtained in 2022			Yields obtained in 2023		
Nitrogen Rate (kg/ha)	Nitrogen Fertilizer	Yield (kg/ha)	Differences to control		Yield (kg/ha)	Differences to control	
			kg/ha	%		kg/ha	%
36	-	7616	Control	-	4496	Control	-
80	Ammonium Nitrate	9487	1871 *	24.6	4935	439 **	9.8
	Urea	9124	1508 *	19.8	5047	551 ***	12.3
	Urea + NutriSphere-N	9598	1982 **	26.0	5245	749 ***	16.7
	UAN	10118	2502 **	32.9	5210	714 ***	15.9
120	Ammonium Nitrate	9671	2055 **	27.0	5209	713 ***	15.9
	Urea	9757	2141 **	28.1	5280	784 ***	17.4
	Urea + NutriSphere-N	11045	3429 ***	45.0	5139	643 ***	14.3
	UAN	10645	3029 ***	39.8	5044	548 ***	12.2
160	Ammonium Nitrate	10022	2406 **	31.6	4772	276	6.1
	Urea	11132	3516 ***	46.2	4946	450 **	10.0
	Urea + NutriSphere-N	11231	3615 ***	47.5	5305	809 ***	18.0
	UAN	10211	2595 ***	34.1	5142	646 ***	14.4
		$LSD_{5\%}$ = 1412.01 kg/ha $LSD_{1\%}$ = 1901.59 kg/ha $LSD_{0.1\%}$ = 2521.16 kg/ha			$LSD_{5\%}$ = 281.88 kg/ha $LSD_{5\%}$ = 379.62 kg/ha $LSD_{5\%}$ = 503.31 kg/ha		

Table 3. Maize grain yields as average values at different nitrogen rates under different climatic conditions in South Romania

Experimental factor	Yields obtained in 2022			Yields obtained in 2023		
Nitrogen Rate (kg/ha)	Yield (kg/ha)	Differences to control		Yield (kg/ha)	Differences to control	
		kg/ha	%		kg/ha	%
36	7616	Control	-	4496	Control	-
80	9582	1966 **	25.8	5109	613 ***	13.6
120	10279	2663 ***	35.0	5168	672 ***	14.9
160	10649	3033 ***	39.8	5041	545 **	12.1
	$LSD_{5\%}$ = 1412.01 kg/ha $LSD_{1\%}$ = 1901.59 kg/ha $LSD_{0.1\%}$ = 2521.16 kg/ha			$LSD_{5\%}$ = 321.25 kg/ha $LSD_{5\%}$ = 429.08 kg/ha $LSD_{5\%}$ = 561.47 kg/ha		

Table 4. Maize grain yields as average values at different nitrogen fertilizers under different climatic conditions in South Romania

Experimental factor	Yields obtained in 2022			Yields obtained in 2023		
Nitrogen Fertilizer	Yield (kg/ha)	Differences to control		Yield (kg/ha)	Differences to control	
		kg/ha	%		kg/ha	%
Ammonium Nitrate	9727	Control	-	4972	Control	-
Urea	10026	299	3.1	5091	119	2.4
Urea + NutriSphere-N	10625	898	9.2	5230	258	5.2
UAN	10325	598	6.1	5132	160	3.2
	$LSD_{5\%}$ = 1735.78 kg/ha $LSD_{1\%}$ = 2337.60 kg/ha $LSD_{0.1\%}$ = 3099.24 kg/ha			$LSD_{5\%}$ = 325.85 kg/ha $LSD_{5\%}$ = 438.83 kg/ha $LSD_{5\%}$ = 581.81 kg/ha		

CONCLUSIONS

Following the research carried out on the chernozem cambic soil from South Romania, the tested fertilizer product with the best results in maize grain yield was Urea with NutriSphere-N, this being followed by fertilizers UAN and Urea, the last place being taken by Ammonium Nitrate. However, taking the Ammonium Nitrate fertilizer as control, the differences obtained by the other fertilizer products are not statistically significant.

The effect of the nitrogen rate on the maize grain yield is very depended by climatic conditions of the year. Thus, in the more climatic favorable year 2022, the highest yield was registered at the nitrogen rate of 160 kg/ha, while in the warm and dry year 2023, the highest yield was registered at the nitrogen rate of 120 kg/ha, but with a small difference compared to the nitrogen rate 80 kg/ha. So, under drought conditions, the nitrogen rate should not be high, as this could be even a limiting yielding factor.

In general, fertilization with nitrogen no matter the rate, fertilizer product and climatic conditions of the year determined obtaining of yield differences assured statistically.

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