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MAIZE GRAIN YIELD UNDER DIFFERENT NITROGEN APPLICATION VARIANTS IN THE GROWING CONDITIONS OF SOUTH ROMANIA

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Abstract

The current climatic changes require the farmers to optimize nitrogen fertilization according to the specific growing conditions of their crops. Choosing the right fertilizer product, rate, time and method of application are essential decisions for farmers. In this context, the aim of this paper is to present the obtained results regarding the maize grain yields at different application method of the nitrogen fraction applied in the vegetation period of the maize plants and at different nitrogen rate split variants under the specific growing conditions of South Romania. The research was carried out in field experiments located in South Romania (44°22' N latitude and 26°89' E longitude), under rainfed conditions in the years 2022 and 2023. The experimental factors were the following: Factor A – application method of the nitrogen fraction applied in the vegetation period of the maize plants (incorporated with the mechanical weeding and surface broadcast); Factor B – nitrogen rate split in two applications with 6 ratios. The obtained results brought attention to the positive effects of the nitrogen rate split between the crop establishment and vegetation period of the maize plants compared to the application of the entire rate at the crop establishment, the split ratio being according to the year climatic conditions.

***Key words**: maize, nitrogen, application method, rate split, grain yield*

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important plants grown in the world from an economic point of view and it is used as a source of food, animal feed and for various industrial applications. Modern agriculture is mainly focused on using the resources with maximum efficiency to ensure a greater productivity for feeding the growing global population (Leonte et al., 2023). A crucial yield limitation factor is fertilization, respectively plant nutrition, which must sustain increasingly high potential hybrids by providing enough nutrients at precise moments in time (Jeffrey & Gyles, 2003). Also, grain maize is an important cash crop for farms without livestock (Finke et al., 1999). As the human population continues to grow, it is becoming highly challenging to increase food production without exacerbating environmental problems and increasing agricultural acreage (Xu et al., 2020).

The significant increases in the cost of fertilizer over the past years make it necessary to have a "minimum quantity-maximum effect" strategy, thus making it essential to place the fertilizer granules as close to the root system as possible to minimize unused fertilizer (Thielicke et al., 2022).

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).

Nutrients are essential for increasing maize yields. 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). 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 nitrogen fertilizer products, the appropriate rate and time of application are essential for farmers. In this respect, split N application is a 4R (Right Source, Right Rate, Right Time, Right Place) nutrient management practice that ensures sufficient N supply when the crop needs it most, minimizing N losses to the environment, while allowing N rate adaptations as the season evolves (Kabir et al., 2021).

The grain yield is influenced by several factors, either they are environmental or technological: for instance, the maize grain yield due to the application of nitrogen in the vegetation period is different according to the preceding crop (Bășa et al., 2016). Also, 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.

The aim of this paper is to present the obtained results regarding the maize grain yields at different application method of the nitrogen fraction applied in the vegetation period of the maize plants and at different nitrogen rate split variants 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 (44°22’ N latitude and 26°89’ 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 of 6.4.

For the period March-September 2022, the average temperature was 17.8°C, respectively 18.6°C 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.

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

Month	Temperature (°C)		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***

The studied biological material was the maize hybrid KWS Kashmir from FAO group 370, which is a simple hybrid designed for intensive production.

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 seed 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 – application method of the nitrogen fraction applied in the vegetation period of the maize plants, with 2 graduations:
    - a1. Incorporated with the mechanical weeding;
    - a2. Surface broadcast;
- Factor B – nitrogen rate split in two applications, with 6 graduations:
    - b1. 120 + 0;
    - b2. 80 + 40 in BBCH 1.6;
    - b3. 40 + 80 in BBCH 1.6;
    - b4. 60 + 60 in BBCH 1.4;
    - b5. 60 + 60 in BBCH 1.6;
    - b6. 60 + 60 in BBCH 1.8.

At sowing, there was used Diammonium Phosphate (DAP) 18:46:0 in a rate of 222 kg/ha of commercial product, which assured 40 kg/ha of nitrogen and 102 kg/ha of phosphorus for all the experimental variants.

The total nitrogen rate was of 120 kg/ha for all the variants, and the different of 80 kg/ha from the 40 kg/ha of nitrogen supplied by the complex fertilizer applied with sowing was split in two fractions, the first one being applied before seed bed preparation and the second one being applied in the vegetation period of the maize plant, respectively in the growth stage of 4 leaves (BBCH 1.4), 6 leaves (BBCH 1.6), and 8 leaves (BBCH 1.8).

The difference of nitrogen for each rate split before seed bed preparation was applied before seedbed preparation under the form of Ammonium Nitrate (NH_4NO_3) with a total nitrogen content of 33.5%. Also, the Ammonium Nitrate was used as nitrogen fertilizer for the nitrogen split applied in the vegetation period of the maize plants (BBCH 1.4, BBCH 1.6, and BBCH 1.8).

The experimental variant 120 + 0 consisted in the application before seed bed preparation of the entire different of 80 kg/ha from the 40 kg/ha of nitrogen supplied by the complex fertilizer applied with sowing. So, this experimental variant consisted in applying the whole nitrogen rate at the crop establishment and 0 nitrogen applied in the vegetation period of the maize plants. This experimental variant was chosen as control variant having into account that it is used at a large scale by the Romanian farmers growing maize.

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.

RESULTS AND DISCUSSIONS

The climate it’s constantly changing from one year to another, especially when we are talking about South of Romania, where in the past 4 years the precipitation is present with small quantities. Under drought or water deficit it is essential to choose the best method of application of the nitrogen fertilizers, the right quantity and the correct split of the rate.

In the more favourable climatic year 2022 in the studied area, the highest maize grain yield was obtained when from the total of

120 kg/ha of nitrogen, 60 kg/ha (half of the nitrogen rate) was applied in the growth stage of 4 leaves (V1 - BBCH 1.4) as surface broadcast, with a difference compared to control variant positive distinct significant (Table 2). Positive difference statistically significant compared to control variant was registered also in the case of applying one third of the nitrogen rate (40 kg/ha) at the crop establishment (before seed bed preparation as Ammonium Nitrate and with sowing as Diammonium Phosphate) and two thirds (80 kg/ha) applied in the growth stage of 6 leaves (V2 - BBCH 1.6) incorporated with the mechanical weeding. Also, a positive difference statistically significant compared to control variant was registered in the case of variant with half of the nitrogen rate applied in the growth stage of 8 leaves (V3 - BBCH 1.8).

In 2022, the smallest grain yield was registered in the case of experimental variant with two thirds of the nitrogen rate (80 kg/ha) applied at the crop establishment and one third (40 kg/ha) applied in the growth stage of 6 leaves (V2 - BBCH 1.6) as surface broadcast (Table 2).

In the less favourable climatic year 2023 in the studied area, the highest grain yield was obtained when two thirds of the nitrogen rate (80 kg/ha) were applied at the crop establishment and one third (40 kg/ha) was applied in the growth stage of 6 leaves (V2 - BBCH 1.6) incorporated with the mechanical weeding (Table 2). Under the climatic conditions of the year 2023, the smallest grain yield was registered in the case of the experimental variant with one third of the nitrogen rate (40 kg/ha) applied at the crop establishment and two thirds of the nitrogen rate (80 kg/ha) applied in the growth stage of 6 leaves (V2 - BBCH 1.6) as surface broadcast.

In both experimental years the maize grain yields were higher in the case of the nitrogen split in the vegetation period incorporated with the mechanical weeding then in the case of the nitrogen split in the vegetation period applied as surface broadcast (Table 2).

The maize grain yield obtained in 2023 is much lower than that obtained in 2022, the year 2023 being warmer and drier than the year 2022 (Table 2 and Table 3).

As average values for the nitrogen methods of application, the highest grain yield was registered in the more favourable climatic year 2022 in the case of the experimental variant 60+60 V3, respectively half of the nitrogen rate applied at the crop establishment and half applied in the growth stage of 8 leaves - BBCH 1.8 (Table 3). In the less climatic favourable year 2023, the highest grain yield was registered in the case of the experimental variant 80+40 V2, respectively two thirds of the nitrogen rate applied at the crop establishment and one third applied in the growth stage of 6 leaves - BBCH 1.6.

CONCLUSIONS

Following the performed research, generally the nitrogen rate split between the crop establishment and vegetation period of the maize plants proved to be more efficacy compared to the application of the entire rate at the crop establishment, the split ratio being according to the year climatic conditions.

In the more favourable climatic conditions, the highest grain yields were obtained by applying half of the nitrogen rate in the vegetation period as surface broadcast or two thirds of the nitrogen rate in the vegetation period incorporated with the mechanical weeding.

In the less favourable climatic conditions, the highest grain yield was obtained by applying one third of the nitrogen rate in the vegetation period incorporated with the mechanical weeding.

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				*Average yield 2022-2023 (kg/ha)*	
Method of application	Nitrogen rate (kg/ha)	Yield (kg/ha)	Differences to control		*Average (kg/ha)*	Yield (kg/ha)	Differences to control		*Average (kg/ha)*		
			kg/ha	%			kg/ha	%			
Integral rate before seedbed preparation	120+0	9849	Control		*9849*	5965	0	0	*5965*	-	*7907.0*
Vegetation split incorporated with the mechanical weeding	80+40 V2	10495	646	6.56	*10622.0*	6789	824 **	13.81	*6324.6*	8642.0	*8473.3*
	40+80 V2	11218	1369 *	13.90		6475	510	8.55		8846.5	
	60+60 V1	10304	455	4.62		6243	278	4.66		8273.5	
	60+60 V2	10313	464	4.71		5858	-107	-1.79		8085.5	
	60+60 V3	10780	931	9.45		6258	293	4.91		8519.0	
Vegetation split applied as surface broadcast	80+40 V2	9474	-375	-3.81	*10508,6*	6104	139	2.33	*5910.4*	7789.0	*8209.5*
	40+80 V2	10316	467	4.74		5376	-589 °	-9.87		7846.0	
	60+60 V1	11372	1523 **	15.46		5938	-27	-0.45		8655.0	
	60+60 V2	10259	410	4.16		5967	2	0.03		8113.0	
	60+60 V3	11122	1273 *	12.93		6167	202	3.39		8644.5	

LSD$_{5\%}$ = 1066.69 kg/ha
LSD$_{1\%}$ = 1445.52 kg/ha
LSD$_{0.1\%}$ = 1935.46 kg/ha

LSD$_{5\%}$ = 543.05 kg/ha
LSD$_{1\%}$ = 735.91 kg/ha
LSD$_{0.1\%}$ = 985.33 kg/ha

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

Nitrogen rate (kg/ha)	Yields obtained in 2022			Yields obtained in 2023			*Average yield 2022-2023 (kg/ha)*
	Yield (kg/ha)	Differences to control		Yield (kg/ha)	Differences to control		
		kg/ha	%		kg/ha	%	
120+0	9849.0	Control	0	5965.0	Control	0	*7907.0*
80+40 V2	9984.5	135.5	1.38	6446.7	481.7	8.08	*8215.6*
40+80 V2	10767.5	918.5	9.33	5925.7	-39.3	-0.66	*8346.6*
60+60 V1	10838.0	989.0	10.04	6090.5	125.5	2.10	*8464.3*
60+60 V2	10286.3	437.3	4.44	5912.3	-52.7	-0.88	*8099.3*
60+60 V3	10951.0	1102.0	11.19	6212.7	247.7	4.15	*8581.8*
Average	*10446.0*	-	-	*6092.2*	-	-	*8269.1*

LSD$_{5\%}$ = 1150.91 kg/ha
LSD$_{1\%}$ = 1549.96kg/ha
LSD$_{0.1\%}$ = 2054.97 kg/ha

LSD$_{5\%}$ = 736.51 kg/ha
LSD$_{1\%}$ = 991.88 kg/ha
LSD$_{0.1\%}$ = 1315.05 kg/ha

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