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FERTILIZATION EFFECTS ON MAIZE CROP IN THE CONTEXT OF CLIMATE CHANGE

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ABSTRACT

A field experiment was conducted during 2015-2019 years at the National Agricultural Research and Development Institute Fundulea, Romania, to investigate the effect of different nitrogen and phosphorus sources on growth, yield and quality of maize (*Zea mays* L.). This research is carried out in long term experiments (over 45 years) under unirrigated conditions. Fertilization, like the basic technological link, ensures a constant flow of nutrients to the crop plant, but the efficiency of applying organic fertilizers is strongly influenced by extreme variations of the climatic conditions. The results showed also that the final maize yields and yield increases were conditioned and limited by specific traits, especially using of mineral and organic fertilizing.

Keywords: fertilization, maize, climate change.

INTRODUCTION

Climate change is already having negative consequences on agricultural crops, by diminishing water resources, decreasing the efficiency of fertilization and affecting its production and quality. Thus, new approaches to research are required at regional and local level with real applicability of the results. One of the basic technological links to obtain high yields is fertilization. These studies have been in the attention of researchers, due to its positive effects on increasing yield and quality and its negative effects on soil, water and human health (Partal and Paraschivu, 2020; Molden et al., 2010; Brevik and Sauer, 2015). The application of a fertilization system correlated with the targeted productivity and the pedoclimatic conditions, can ensure the necessary supply of nutrients and leads to the premise of a successful crop (Agegnehu et al., 2016; Alagele et al., 2019). Previous research has focused on the study of fertilizer effects, emphasizing yield fluctuations depending on the crop, variety or hybrid, climatic conditions and soil (Frye and Thomas, 1991; Petcu et al., 2003; Sin and Partal, 2010). Productions recorded on unfertilized plots in long-term studies have shown that natural soil fertility decreases over time (Yang et al., 2004; Fan et al., 2005). Optimizing the plant nutrition system is necessary in sustainable agricultural systems that lead to soil conservation and low inputs. In order to verify and strengthen these studies, the data obtained in the period 2015-2019 at NARDI Fundulea were processed and followed the influence of mineral and organic fertilizers on the evolution of maize crop.

MATERIAL AND METHODS

Researches was conducted in a long time trails in unirrigated conditions on chernozem type of soil at NARDI Fundulea. The

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experiment was placed on a uniform soil in terms of microrelief, for maize crop. The variants were: Factor A - phosphorus fertilizer with 4 rates: 0, 40, 80, 120 kg/ha P_2O_5 basal applied; Factor B - organic fertilizers: without organic fertilizers, plant debris (3-5 t/ha wheat straws), manure (20 t/ha applied in autumn); Factor C - nitrogen fertilizer with 5 rates: 0, 50, 100, 150, 200 kg/ha N. Statistically analysis of the data was evaluated using analysis of variance (ANOVA). The significance of the effects of the applied treatments was determined using the F test. Multiple comparisons of means were performed using the Duncan multiple interval test at $P \leq 0.05$.

Climatic conditions

Climatic data showed significant variations during the experimentation period. It was observed that the climatic conditions corroborated with the technological elements strongly influenced the yield. For the experimental period (2015-2019), the precipitations registered variable quantities compared to the multiannual average value, with deficient distribution during the vegetation period, registering two years with heavy rains, two years of drought and one normal year. Water stress was observed during summer/autumn, influencing crop development. The rains characterized the year 2017 (+198 mm above the average multiannual value). It was observed that the air temperatures were 1-2.3°C above the multiannual average value. Thus, in the agricultural years 2018 and 2019, the high air temperatures in the summer months related to water stress lead to a decrease in crop yield (Figure 1). During the experimentation period, three agricultural years recorded very large variations in temperatures and precipitation, compared to the multiannual average and had a negative influence on the growth and development of crop plants.

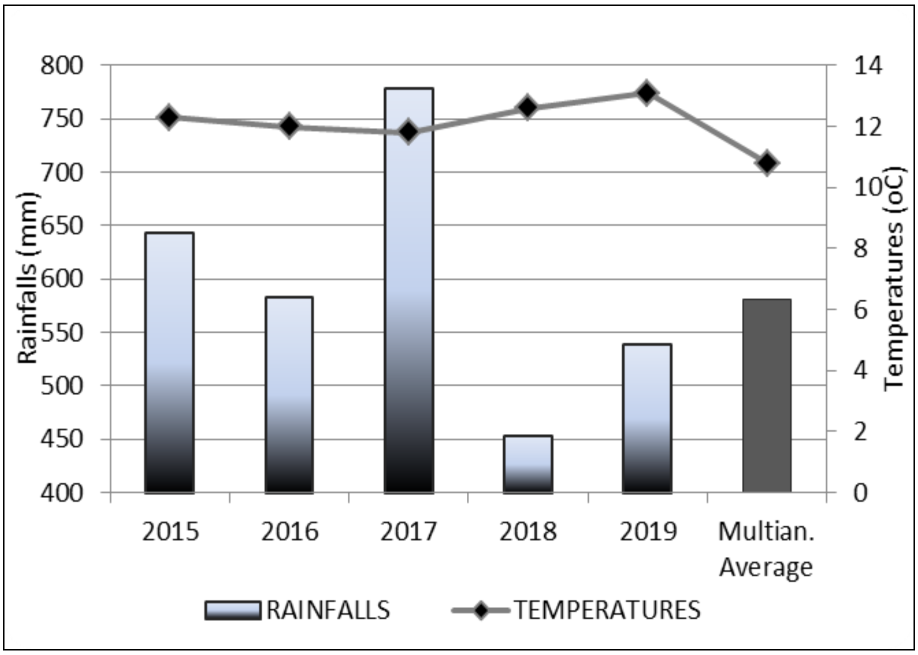

Figure 1. The evolution of the rainfalls and temperatures during 2015-2019 years to NARDI Fundulea area

RESULTS AND DISCUSSION

Analysis of variance revealed distinct significant values, both under the influence of experimental factors and their interactions based on the F test, which compared to the experimental error showed that yields fluctuated from year to year due to climatic conditions and the fertilization system applied. The efficiency of the application of organic fertilizers was strongly influenced by the type and amount of precipitation and their distribution during the vegetation period of the maize crop (Table 1).

Table 1. ANOVA for maize average yields on 5 years (2015-2019)

Factor	SP*	DF	S^2	Fc value and significations
A - year	4120	7	635	2109**
Error a	6.00	21	0.30	
B - phosphorus fertilizer	101	3	36.1	156**
A*B	63	21	3.20	13.20**
Error b	15.1	70	0.23	
C - organic fertilizers	142	2	77.0	409**
A*C	99	14	7.60	40.20**
B*C	10.1	6	1.90	10.09**
A*B*C	52	40	1.50	8.20*
D - nitrogen fertilizer	1988	4	507	2580**
A*D	409	28	15.8	85.00**
B*D	10.2	12	0.99	5.50**
A*B*D	48.9	82	0.62	3.40**
C*D	62.0	8	7.20	41.1**
A*C*D	57.9	56	1.09	6.01**
B*C*D	17.6	24	0.80	4.45**
A*B*C*D	92	160	0.61	3.35**
Error c	226	1102	0.19	

SP - sum of squares; DF - degree of freedom.

The average yields registered significant decreases depending on the fertilization system applied and the climatic conditions. Thus, the lowest values of yield were recorded in 2018 and 2019. The increase in yield due to the application of manure varied from 2.2 t/ha to 3.7 t/ha compared to variant without organic fertilizers and from 1.1 t/ha to 2.4 t/ha to the variants of plant debris. The largest variations in average yields were recorded in 2017, when rainfall in large quantities increased the efficiency of fertilizer recovery (Figure 2).

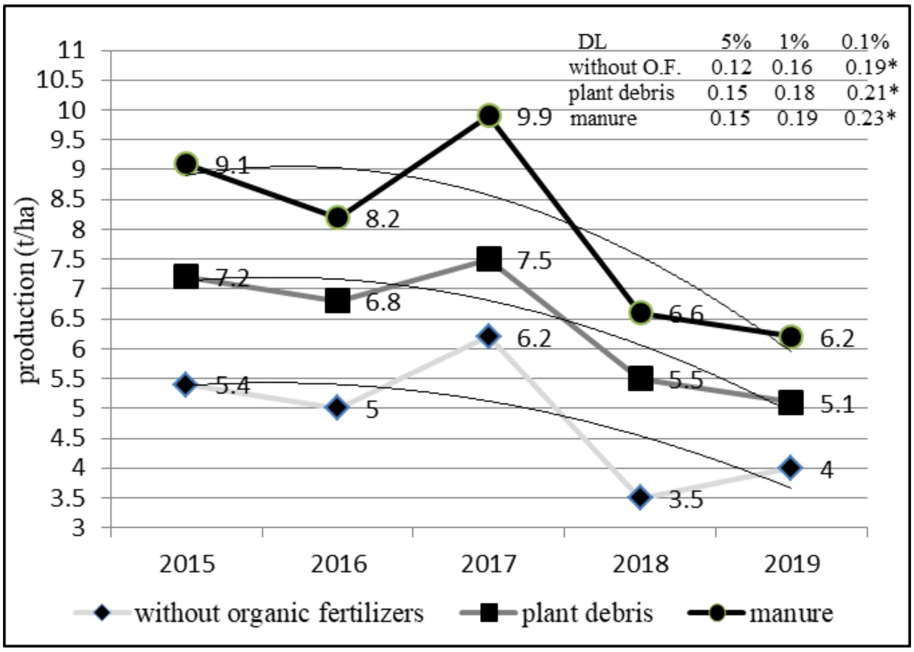

Figure 2. Average maize yields under the influence of climatic conditions and a mineral fertilization fund

The production equations obtained as an average in the period 2015-2019 have statistical assurance coefficients with significant values, which reveals that the doses of mineral fertilizers applied showed a positive efficiency. The highest level of correlation ratio was registered for the variant with vegetable residues (R^2=0.786), due to the efficient capitalization of a mineral fertilizer fund of $N_{150}P_{80}$ and the climatic conditions during the vegetation period (Table 2).

Table 2. Equations and correlation ratios between average yields obtained and organic fertilization applied to maize crop (2015-2019)

Experimental variants background $N_{150}P_{80}$	Production equation	Correlation report
Without organic fertilizer	$y = -0.15x^2 + 0.47x + 5.06$	$R^2 = 0.461$
Plant debris	$y = -0.192x^2 + 0.607x + 6.72$	$R^2 = 0.786$
Manure	$y = -0.285x^2 + 0.974x + 8.22$	$R^2 = 0.657$

The variations registered at the level of productions, as an average of the experimentation period, show us that the most important limiting factor is nitrogen fertilization. Thus, the very significant influence of unilateral nitrogen fertilization on average yields was observed. The increase in yield varied from 0.4 t/ha to 2.4 t/ha. Gradual nitrogen flows at 150 kg/ha N ensured significant yield increases. When higher rates of nitrogen were applied (over 150 kg/ha N), the increase in yield increased only when the plant debris were left on the ground. Plant debris brings a low amount of nitrogen to the soil, but plays an important role in maintaining the amounts of organic matter and in the synthesis of the compounds that help form humus. Stable, high and economically optimal productions were registered following the application of manure by decreasing the doses of nitrogen and phosphorus from the added chemical fertilizers (Figure 3).

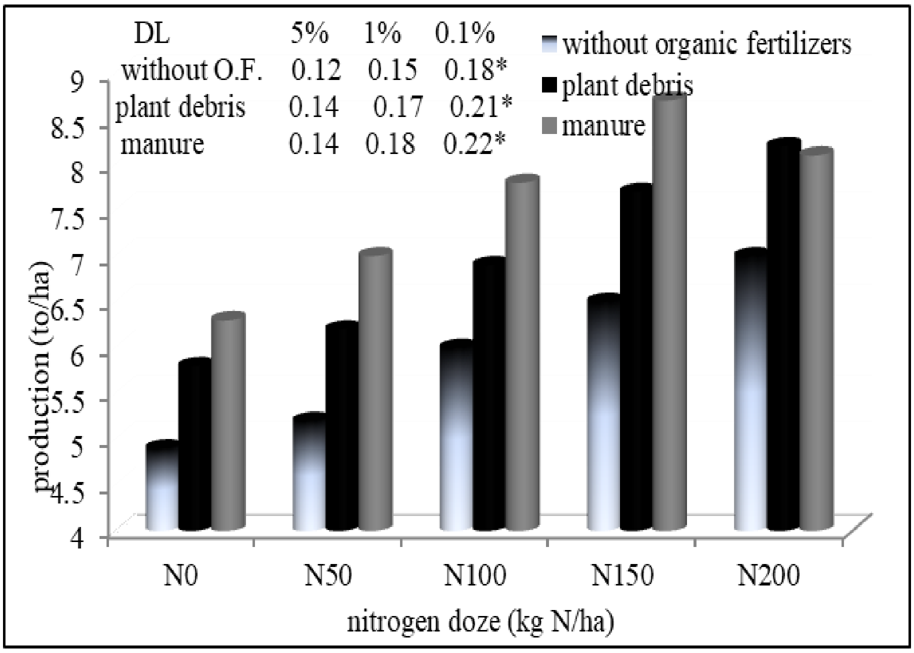

Figure 3. The influence of nitrogen fertilizing on maize average yield (2015-2019)

Research has shown that of the total amount of fertilizer applied, only part is used by the crop plant. Analyzing the average maize production, one can observe the very significant influence of phosphorus fertilization. The increase in yield due to unilateral phosphorus fertilization ranged from 0.3 t/ha to 3.4 t/ha, depending on the experimental variant. The increase in yield was very significant when phosphorus fertilizers were applied to plots previously fertilized with manure. Applying an amount of 80 kg/ha P_2O_5 the yield was 8.0 t/ha, followed by the variant with 120 kg/ha P_2O_5 with 7.8 to/ha (Figure 4).

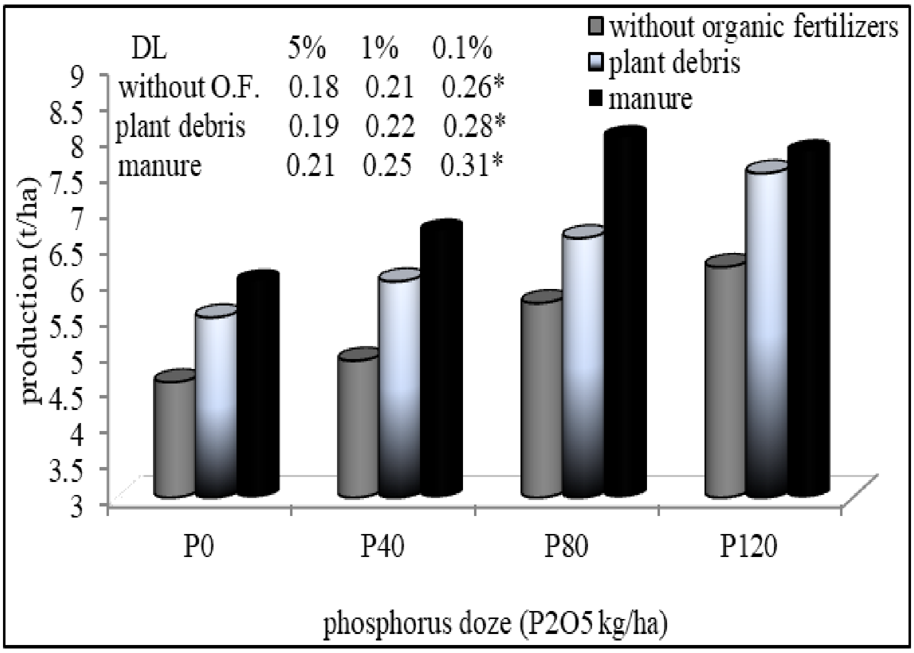

Figure 4. The influence of phosphorus fertilizing on maize average yield (2015-2019)

Fertilization is a very important technological link both in the development of crop plants and for the growth and stability of final production. On non-fertilized plots, yields ranged from 4.0 t/ha to 6.1 t/ha. When economic rates of nitrogen were applied, yields ranged from 6.5 t/ha to 10.1 t/ha, and yield increases ranged from 2.5 t/ha to 4.0 t/ha compared with unfertilized plots. The economic rates of nitrogen were between 125-155 kg/ha N. When nitrogen fertilizer is unilateral, the increase in yield ranged from 10.2 kg cereals/N kg to 22 kg cereals/N kg, while nitrogen fertilization was applied on batches previously fertilized with phosphorus causes yield increases, which ranged from 10 kg grains/kg NP to 16 kg grains/kg NP. It has been observed that in favorable climatic years the efficiency coefficient of nitrogen increases to 51% (Table 3).

Table 3. The influence of nitrogen and phosphorus fertilizing on maize yield (t/ha)

Specification	Maize crop				
	2015	2016	2017	2018	2019
Control (N_0P_0)	5.05	4.10	6.10	4.00	4.97
N_0P_{80}	5.90	5.25	6.53	5.02	5.07
$N_{50}P_{80}$	6.55	6.00	7.77	5.76	6.20
$N_{100}P_{80}$	7.42	7.75	9.78	7.01	6.98
$N_{150}P_{80}$	8.43	8.00	10.3	7.77	8.08
$N_{200}P_{80}$	8.15	8.00	10.0	7.70	7.72
Economically efficient yield (t/ha)	8.10	7.80	10.1	6.50	6.61
Economically nitrogen doses (kg/ha)	142	155	155	125	130
Yield increase for 1 kg N	17.0	16.0	22.0	10.2	14.0
Yield increase for 1 kg NP	13.5	15.0	16.0	10.0	11.1
Nitrogen efficiency coefficient (%)	40.0	38.0	51.0	22.0	29.0

CONCLUSIONS

By forecasting the climatic conditions and the correct associated of the technological elements in accordance with the soil characteristics, the premises of a good environment for the potential genetic manifestation of plants can be created, according to the current requirements regarding the production capacity.

The yields for the same fertilizing variant ranged from 1.51 t/ha to 2.80 t/ha depending on the influence of the nitrogen fertilizers efficiency and the climatically conditions. Organic fertilizers cause a decrease in optimal doses of nitrogen, leading to yields that ranged from 1.0 t/ha to 3.70 t/ha.

For maximum application of nitrogen and phosphorus fertilizers, they should be applied by mid of May, as maize crop begins to have the maximum consumption of nutrients and water. The coefficients of nitrogen efficiency ranged from 25% to 55%, the highest value was recorded in the years with heavy rains, leading to high yields.

Fertilization has had a positive effect on the development of production potential especially in rainy years and could improve the fertility of the soil and increase the efficiency of using precipitation in all stages of plant growth to obtain a satisfactory yield.

The best rate of use of nitrogen and phosphorus to increase the production and efficiency of precipitation was in the climatic conditions of 2015 and 2017.

Integrated or associated application of NP fertilizers, plant debris and manure is an important strategy to maintain and/or increasing nutrients balance of soil and descreas the potential for pollution of the environment.

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