MAIZE GRAIN YIELD AT DIFFERENT COMPLEX FERTILIZERS AND APPLICATION METHODS UNDER GROWING CONDITIONS OF SOUTH ROMANIA

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Abstract

Complex fertilizers are an important tool to enhance productivity of the maize plants and their ability to support stress factors, especially in the present when climate change has become the biggest global challenge to agriculture and food production. Nowadays, the selection of the right complex fertilizer products, the appropriate rate and time of application are essential for farmers to make efficient management decisions. In this context, the aim of this paper is to present the obtained results regarding the influence of different types of complex fertilizers depending on different method of application on maize grain yield 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 – 2 types of fertilizer application method (a1. Banded with sowing; a1. Surface broadcast + incorporation), Factor B – 3 complex fertilizer products (b1. DAP 18:46:0; b2. DAP 18:46:0 treated with AVAIL; b3. Complex fertilizer 14:40:0+7S). The obtained results brought attention to the positive effects on the maize grain yield of the protected product DAP Avail 18:46:0 when it was applied banded with sowing. The effect of the complex fertilizers on the maize grain yield is depended of the climatic conditions of the year. The better water supply of maize plants gives them the possibility to use in more efficient way the nutrients from the soil.

Key words: maize, grain yield, complex fertilizer,

Being one of the most important crops, maize (*Zea mays* L.) is cultivated in many regions of the world (Erenstein O. *et al*, 2013) and also, it is one of the most important crops in Romania, ranking the first place as cultivated area with 2.4-2.7 million hectares in the period 2012-2022. Maize 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. Also, grain maize is an important cash crop for farms without livestock (Finke C. *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 L.C., Ion V., 2022).

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 Z. *et al*, 2020). Therefore, the research has to provide practical solutions to increase the yields and to make them less dependent of the environmental conditions.

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 M. *et al*, 2023). 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 W.M., Roberts T.L., 2012). For this particular reason maize has been a subject of study for many researchers. 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 F. *et al*, 2021).

There are many new types of fertilizers (slow-release fertilizers, microbial fertilizers, and organic fertilizers, among others) that are effective in increasing yield and protecting the environment (Du Y.D. *et al*, 2020). Slow or controlled release fertilizers have been researched and used more and more widely, they being effective in reducing nutrients loss and making a better use of the

nutrients. One important type of this kind of fertilizers is coated fertilizers, which are physically prepared by coating granules of conventional fertilizers with various materials that reduce their dissolution rate. The release and dissolution rates of water-soluble fertilizers depend on the coating materials (Wu S.L. *et al*, 2008). The new type of fertilizers implies, as in the case of any new technology, higher costs, and therefore they have to be used in an appropriate way.

Fertilizers play a crucial role in modern agriculture to increase maize yield (Mulyati *et al*, 2021), they increasing maize yields both quantitatively and qualitatively, this being because fertilizers increase the availability of nutrients, plant health and suppress disease growth (Naomi M.R. *et al*, 2021). The nitrogen (N), phosphorus (P) and potassium (K) are the three most widely used elements for improving maize yield (Wu L.Q. *et al*, 2015). The phosphorus plays an important role in the transfer of energy in plant cells. It stimulates root development and increases nitrogen uptake at the beginning of growth. Phosphorus is also known to play a role in the formation of flowers, fruits and seeds. In using of phosphate fertilizer in the field farmers often does not pay attention to the appropriate dosage.

At present, most studies have shown that the application of nitrogen, phosphorus and potassium fertilizers has a significant impact on soil fertility. (Gaudin et al. 2015). Drought is one of the main constraints in maize cultivation in South Romania, which is the most important Romanian growing area for maize (Ion V. *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 and phosphorus fertilization. It should be noted that not only crop yields (Ray D.K. *et al*, 2015), but also the efficiency of the use of resources, in particular nutrients from soil and fertilizers (Ryan J. *et al*, 2012) are influenced by the weather conditions.

Complex fertilizers can supply crops in several nutrients in appropriate amounts and proportions and their rates are related to soil abundance in available essential nutrients: phosphorus, potassium and magnesium (Nogalska A. *et al*, 2012). Complex fertilizers are an important tool to enhance productivity of the maize plants and their ability to support stress factors, especially in the present when climate change has become the biggest global challenge to agriculture and food production. Nowadays, the selection of the right complex fertilizer products, the appropriate rate and time of application are essential for farmers to make efficient management decisions. In this context, the aim of this paper is to present the obtained results regarding the effects of different complex fertilizers and their application methods at maize under the specific growing conditions of South Romania.

MATERIAL AND METHOD

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 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	2022
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 with kernera 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 seedbed was made with a combinatory one day before sowing. The sowing was performed 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 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 organized as subdivided plots with 3 replications being of type 2 x 3 with the following experimental factors:

- Factor A – Fertilizer application method, with 2 graduations:
  - a1. Banded with sowing;
  - a2. Surface broadcast + incorporation.
- Factor B – Complex fertilizer product, with 3 graduations:
  - b1. DAP 18:46:0;
  - b2. DAP AVAIL 18:46:0;
  - b3. Complex fertilizer 14:40+7S.

In the variants of surface broadcast, the fertilizers were broadcasted before seedbed preparation and were incorporated by this tillage. In the banded variants, the fertilizers were applied with sowing.

DAP 18:46:0 – Diammonium phosphate [$(NH_4)_2HPO_4$] is one of the most concentrated phosphate-based fertilizer, this being the world's most widely used phosphorus fertilizer. It is perfect for any agriculture crop to provide full phosphorus nutrition throughout crop growth and development, as well as a starter dose of nitrogen. It can be applied in autumn with tilling and in spring during sowing, as well as for pre-sowing cultivation. Dissolving in soil, it provides temporary alkalization of pH of the soil solution around the fertilizer granule, thus stimulating better uptake of phosphorus from the fertilizers on acid soils.

DAP AVAIL 18:46:0 is a DAP fertilizer treated with AVAIL© which is a specific material, designed as a mode of action to attract divalent and trivalent cations, not being affected by temperatures and soil reaction. AVAIL© creates a strongly negatively charged shield in the microenvironment around the granules and once in the soil, minimizes the concentration of potentially reactive cations in the immediate vicinity of the applied phosphorus fertilizers. AVAIL© is soluble in water but very little mobile from its contact area with the fertilizer, being a copolymer (macromolecule composed of several distinct repeating units called monomers, which can be linked together in various forms and through various chemical bonds) with long chain dicarboxylic acid (organic compound containing two carboxyl functional groups).

Complex fertilizer 14:40:0+7S is a fertilizer that also provides an important Sulphur (S) supply.

DAP 18:46:0 and DAP AVAIL 18:46:0 were used in a rate of 200 kg/ha of commercial product, which assured 36 kg/ha of nitrogen and 92 kg/ha of phosphorus (P_2O_5). Complex fertilizer 14:40:0+7S was used in a rate of 230 kg/ha which assured the same rate of P_2O_5, respectively 92 kg/ha, but it assured less nitrogen, respectively the rate of 32.2 kg/ha.

In total, the nitrogen rate assured within the experiments were of 120 kg/ha, the difference of the nitrogen from the complex fertilizer being assured by ammonium nitrate (NH_4NO_3) with 33.5 nitrogen content applied in the growth stage of 8 leaves of the maize plants.

Each experimental variant consisted of 126 m^2 resulting from 18 maize 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.

RESULTS AND DISCUSSIONS

Due to the climate changes, in general but especially when it comes to South Romania, there is necessary for farmers to adapt and find the best and most efficient fertilization options.

The experimental variant DAP 18:46:0 applied with sowing was choose as control variant because this fertilizer product and method of application is the most use by farmers growing maize in Romania.

The influence of fertilization with complex fertilizers had an important impact on the maize plant growth at all experimental variants. In both experimental years, the best fertilization variant was those with DAP Avail 18:46:0 applied with sowing, this variant giving the highest grain yields, respectively 12514 kg/ha in 2022 (a yield increase of 16.74% compared to control variant) and 6777 kg/ha in 2023 (a yield increase of 11.7% compared to control variant) (*table 2*).

Except DAP Avail 18:46:0 variant, the other two fertilizer products, respectively DAP 18:46:0 and complex fertilizer 14:40+7S realized better grain yields when they were broadcasted before seedbed preparation and were incorporated by this tillage (*table 2*).

In the year 2022, there were not registered differences statistically significant compared to

control variant, but in 2023 the complex fertilizer DAP Avail 18:46:0 realized a difference very significant when it was applied banded with sowing and a difference distinct significant when it was broadcasted before seedbed preparation and were incorporated by this tillage. In 2023, also the fertilizer product DAP 18:46:0 realized a difference distinct significant when it was broadcasted before seedbed preparation and were incorporated by this tillage.

Table 2

Grain yield at maize at different fertilizer application methods and complex fertilizer products under different climatic conditions in South Romania (2022 and 2023)

Experimental factor		Yields obtained in 2022			Yields obtained in 2023		
Fertilizer application method	Complex fertilizer product	Yield (kg/ha)	Differences to control		Yield (kg/ha)	Differences to control	
			kg/ha	%		kg/ha	%
Banded with sowing	DAP 18:46:0	10720	Control	-	6067	Control	-
	DAP AVAIL 18:46:0	12514	1794	16.74	6777	710 ***	11.70
	14:40:0 + 7S	10291	-429	-4.00	5999	-68	-1.12
Surface broadcast + incorporation	DAP 18:46:0	11100	380	3.54	6587	520 **	8.57
	DAP AVAIL 18:46:0	11124	404	3.77	6635	568 **	9.36
	14:40:0 + 7S	11342	622	5.80	6196	129	2.13
		$DL_{5\%}$ = 2189.93 kg/ha $DL_{1\%}$ = 3070.32 kg/ha $DL_{0.1\%}$ = 4339.65 kg/ha			$DL_{5\%}$ = 325.25 kg/ha $DL_{1\%}$ = 456.01 kg/ha $DL_{0.1\%}$ = 644.54 kg/ha		

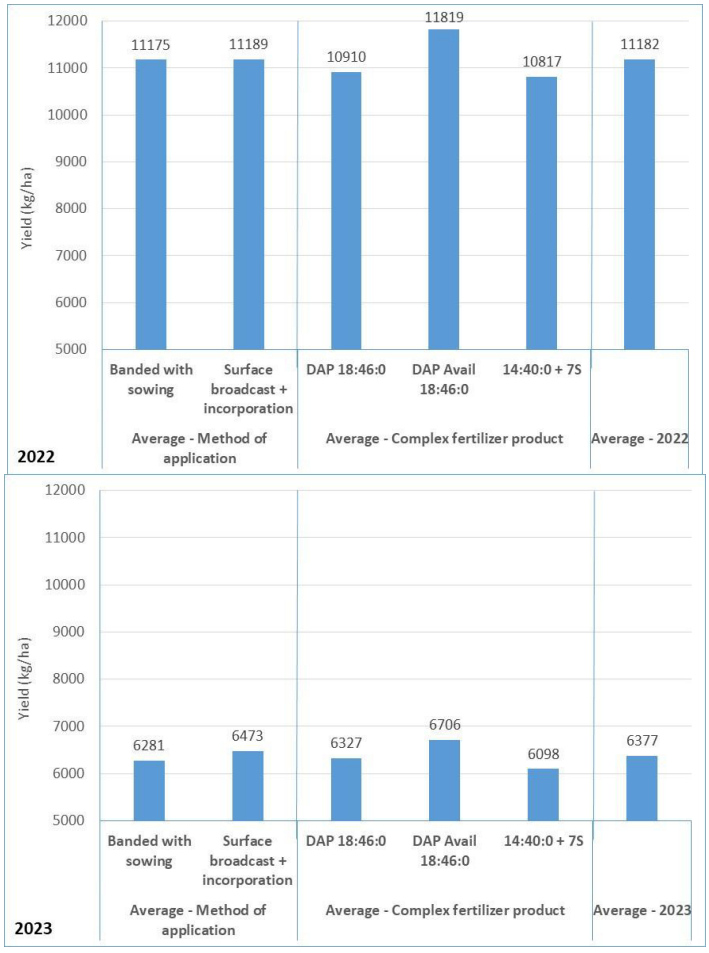

Figure 1 **Average grain yields for fertilizer application methods, complex fertilizer products and years of study in South Romania**

As average values, the grain yields obtained at the two fertilizer application methods were almost equal in 2022 and a bit more evident under the less favorable climatic conditions of the year 2023 (characterized as being warmer and drier than the year 2022) in the favor of surface broadcast before seedbed preparation and incorporation by this tillage (*figure 1*).

The average values for the complex fertilizer products put into evidence the superiority of the protected product DAP AVAIL 18:46:0, but also drew attention to the complex fertilizer 14:40:0 + 7S, which despite the Sulphur supply determined the smallest average grain yield (*figure 1*).

The average yield obtained in 2022 (11182 kg/ha) is much higher than in 2023 (6377 kg/ha) (*figure 1*), this being due to the higher rainfall in 2022 during the vegetation period of the maize plants, which totaled 281.7 mm, compared with 238.4 mm in 2023. In fact, all the average yields either reported to the application method of the fertilizers or the complex fertilizer products are higher in 2022 than in 2023 (*table 2*). Practically, the better water supply of maize plants gives them the possibility to use in more efficient way the nutrients from the soil.

CONCLUSIONS

Following the research carried out on the chernozem cambic soil from South Romania, it resulted that the complex fertilizer product with the best results in maize grain yield was the protected product DAP Avail 8:46:0 in both experimental years of study when it was applied banded with sowing.

The other two fertilizer products, respectively DAP 18:46:0 and complex fertilizer 14:40+7S realized better grain yields when they were broadcasted before seedbed preparation and were incorporated by this tillage.

The effect of the complex fertilizers on the maize grain yield is depended of the climatic conditions of the year.

The better water supply of maize plants gives them the possibility to use in more efficient way the nutrients from the soil.

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