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EFFECTS OF DIFFERENT COMPLEX FERTILIZERS AND THEIR APPLICATION METHODS AT SUNFLOWER

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Abstract

Sustainable agriculture is correlated with the rational use of fertilizers, mineral nutrition being one of the main production factors that directly influence the achievement of safe, constant, efficient and quality agricultural production. The use of modern, intensive, but equally environmentally friendly technologies can ensure the production objectives of farmers, ensuring the profitability of activities carried out in compliance with production and environmental protection norms. The aim of this paper is to present the obtained results regarding the effects of different complex fertilizers and their application methods at sunflower under the specific growing conditions of South-Est Romania. In this respect, field experiments were performed in Dobrogea region from South-East Romania, under rainfed conditions in the years 2022 and 2023. The experimental factors were the following: Factor A – Application methods, with 2 graduations: a1 = Surface broadcast + incorporation; a2 = Banded with sowing; Factor B – Complex fertilizer product, with 3 graduations: b1 = NPK 20-20-0; b2 = Duofertil Eurocereal 34; b3 = DAP (18-46-0). The complex fertilizer Duofertil Eurocereal 34 proved to assure the highest grain yields especially when it was broadcasted and incorporated at the seedbed preparation, but the average differences between the experimented complex fertilizers are not statistically significant. Surface broadcast of the experimented fertilizers followed by their incorporation through the seedbed preparation proved to be more efficient then the banded fertilizer application with sowing regardless of the climatic conditions of the experimented year.

Key words*: sunflower, fertilization, complex fertilizer, application method, yield.*

INTRODUCTION

Being one of the most important oil plants on the globe and the most important one in Romania, sunflower has been a subject of study for many researchers internationally and nationally. The carried out research has aimed the elucidation of many theoretical and applied aspects related to this important cultivated plant, but still there are a lot of issues to be discovered, better understood, or clarified.

The use of modern, intensive, but in the same time environmentally friendly technologies can ensure the profitability of farmers' activities carried out in compliance with production and environmental protection rules. Therefore, in recent years, more and more attention is being paid to assessing the effect of fertilization considering global warming to ensure sustainable soil fertility management (Tănase et al., 2022), efficiency and sustainability of farmers' activities. Undoubtedly, fertilization is one of the major factors that could increase sunflower yield (Shoghi-Kalkhoran et al., 2013). Nutrient management is one of the main factors that influence sunflower achene yield, achene oil, and fatty acid contents (Mahmood, 2021). But, the need for nutrients for yield formation depends both on the specific soils and climatic conditions and on several other factors (Gerassimova et al., 2023). Practically, fertilization is truly effective if it is in compliance with the nutritional requirements of the plants and the soil properties.

To attain maximum yield, the sunflower crop requires fertilizers (Abubaker et al., 2020). Sunflower reacts well to nitrogen fertilization and nitrogen excess lowers the seed oil content and plant resistance to diseases, while balanced phosphorus and potassium fertilization increase yield and oil content in seeds (Gerassimova et al., 2023). Nitrogen levels significantly affect the total number of grains head^{-1}, grain setting efficiency, grain yield, 1000-grains weight, and oil yield of sunflower (Modanlo et al., 2021). Phosphorus fertilization increases the yield of achenes and yield of oil (Soares et al., 2020).

Generally, the imbalance use of fertilizer has been responsible for low fertilizer response (Babu et al., 2014), this being one of the major

causes of low yield of sunflower (Tahir et al., 2017).
Band placement of the fertilizer at the seed level resulted in the largest and most efficient use of applied phosphate as compared to placement below the seed or mixed with the soil (Warder & Vijayalakshmi, 1974).
The use of new types of fertilizers implies, as in the case of any new technology, higher costs. As such, naturally these elements defined as being innovative are adopted by farmers initially within the crop technologies of some species that bring a higher added value. One of the best candidates in this regard is the sunflower crop for the researched area, where even increases in the yield of hundreds of kg per hectare can prove to be significant from an economic point of view.
The aim of this paper is to present the obtained results regarding the effects of different complex fertilizers and their application methods at sunflower under the specific growing conditions of South-Est Romania.

MATERIALS AND METHODS

The research was carried out in Dobrogea region from South-East Romania, respectively in Cerna commune from Tulcea county, and consisted in field experiments performed in rainfed conditions in the years 2022 and 2023.
The field experiments were organized as subdivided plots with 3 replications being of type 2 x 3 with the following experimental factors:
- Factor A – application methods, with 2 graduations:
  - a1 = Surface broadcast + incorporation;
  - a2 = Banded with sowing.
- Factor B – complex fertilizer product, with 3 graduations:
  - b1 = NPK 20-20-0;
  - b2 = Duofertil Eurocereal 34;
  - b3 = DAP (18-46-0).

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 in furrows 5 cm from and 5 cm deeper than the seeds.
NPK 20-20-0 is produced by Azomureș company in Romania and it is a classic fertilizer with a content of 20% nitrogen (11.3% as NH_4^+ and 8.7% as NO_3^-) and 20% phosphorus (63% water soluble).
Duofertil Eurocereal 34 (NPK Eurocereal 10-24-0) is part of the Duofertil fertilizers created by the research department of Timac Agro. It contains the MPPA DUO specificity, which is an association between the MPPA complex (European patent 945000107) and the physiological agent, acting as a phytoregulatory precursor XCK [European patent EP11447706(A2)]. MPPA is a natural complex based on extracts of organic origin containing solubilized polyphenolic molecules of different molecular mass. Thanks to the molecules in MPPA, phosphorus is protected against any type of degradation in a similar way to chelation. XCK stimulates the production of amino acids forcing the roots to produce exudates (of the type of amino acids) called phytoregulatory precursors with a role in cell division at the root level. Duofertil Eurocereal 34 contains 10% nitrogen as ammonium (NH_4^+), 24% P_2O_5 (10.1% water-soluble), 20% SO_3 (water soluble sulfur anhydride), 0.1% Bor, and 0.1% Zinc.
DAP (18-46-0), respectively Diammonium Phosphate [$(NH_4)_2HPO_4$] is the world's most widely used phosphorus fertilizer. It is produced in Morocco and contains 18% nitrogen as ammonium (NH_4^+) and 46% P_2O_5 (min. 43% water soluble).
All the experimental variants were based on a total of 70 kg/ha of nitrogen and 70 kg/ha of P_2O_5. So, the experimented fertilizers were calculated to cover the necessary rate of 70 kg/ha of P_2O_5. According to each complex fertilizer product, respectively to its nitrogen content, the difference of the nitrogen up to 70 kg/ha was applied as ammonium nitrate (34.4% nitrogen content) through surface broadcasting before seedbed preparation.
Each experimental variant had 67.2 m^2 in size which consisted of 12 rows of plants with 70 cm between rows resulting in a width of 8.4 m and 8 m of length along the rows.
The preceding crop was maize. Tillage in the experimental field consisted in a harrowing work performed after harvesting the preceding crop, and in October there was performed the ploughing at 20 cm depth. The ploughing was followed in Autumn by a harrowing work and in Spring there was performed the seedbed

preparation before sowing, this being made with a combinatory.
Sowing was performed on the 9th of April in 2022 and on the 3rd of May in 2023. The assured plant density was 64,000 plants per hectare.
The sunflower hybrid used in the research was SY Onestar CLP, a hybrid with an exceptional production potential, adaptable and stable in different growing conditions.
The weed control was performed by applying the herbicide Pulsar 40 (Imazamox 40 g/l) in a rate of 1.2 l/ha in the growing stage of 6 leaves of sunflower plants.
For controlling the sunflower diseases, there was applied the fungicide Pictor Active (Boscalid 150 g/l and Pyraclostrobin 250 g/l) in a rate of 1 l/ha in the growing stage of 10 leaves of sunflower plants.
In the growing stage of 8 leaves of sunflower plants, there was used the foliar fertilizer Lebosol Nutrifos, which contains 3% N, 30% P_2O_5 and 7% Zn, in a rate of 4 l/ha.
The performed determinations whose results are presented in the present paper were the plant height and the grain yield (kg/ha) reported at 9% moisture content.
The geographical coordinates of the research location determine its inclusion in the temperate continental climate zone. So, the climate is characterized by high temperatures in summer and sometimes very low in winter. The average annual temperature is around 10.7ºC.
Regarding the temperatures registered during the vegetation period of the sunflower plants, compared to the year 2022, in the year 2023 the months March, July and August were warmer, while the months April, May and June were colder (Table 1). As average values for the period March-August, the year 2023 with 17.2ºC was warmer that the year 2022 with 16.8ºC.
Regarding the rainfall registered during the vegetation period of the sunflower plants, the year 2022 with 162 mm was droughter than the year 2023 with 250 mm. In the year 2023, after a drought month March with only 8 mm rainfall, there followed a rainy month April with 125 mm. As a consequence, in 2023 the sowing was significantly delayed compared to usual sowing period for the studied area, which is between end of March and beginning of April. Thus, in 2023 the sowing was performed on the 3rd of May. In both experimental years, the months July but especially August were characterized by small amounts of rainfall.
In the studied area, the specific soil is carbonate chernozem with 2.5% humus content and pH of 7.8-8.1.

Table 1. Climatic conditions during sunflower plant's vegetative period at Cerna, Tulcea county, Romania

Month	Temperature (ºC)		Rainfall (mm)	
	2022	2023	2022	2023
March	3.4	7.8	32	8
April	11.1	10.2	15	125
May	16.8	15.5	49	36
June	21.8	19.8	34	41
July	23.5	24.7	20	25
August	24.2	25.4	12	15
Average/Sum	***16.8***	***17.2***	***162***	***250***

RESULTS AND DISCUSSIONS

Due to the climate changes, in general but especially when it comes to South-East Romania, which is one of the driest area in the country, there is necessary to adapt and find the best and most efficient fertilization options.
In the research carried out, the complex fertilizer Duofertil Eurocereal 34 broadcasted and incorporated at the seedbed preparation assured the highest yields in both experimental years, respectively 2574 kg/ha in 2022 and 2768 kg/ha in 2023, with significant differences (+37% in 2022 and +33% in 2023) compared to the average yield of all the experimental variants. In fact, the complex fertilizer Duofertil Eurocereal 34 determined the highest yields at both application methods (Table 2).
The average yield obtained in 2023 is higher than in 2022, respectively 2081 kg/ha in 2023 and 1873 kg/ha in 2022, this being the result of the higher rainfall in 2023 during the vegetation

period of the sunflower plants, which totaled 250 mm, compared with 162 mm in 2022. In fact, all the average yields either reported to the application method of the fertilizers or the complex fertilizer products are higher in 2023 than in 2022 (Figure 1). Practically, the better water supply of sunflower plants gives them the possibility to use in more efficient way the available nutrients.

Among the two application methods of the experimented fertilizers, the surface broadcast followed by the incorporation of the fertilizers through the seedbed preparation proved to be more efficient regardless of the climatic conditions of the experimented year (Figure 1).

Among the three complex fertilizer products, Duofertil Eurocereal 34 assured the highest yields in both experimental years, this being followed by NPK 20:20:0 and DAP (18-46-0). It has to be mentioned that even there are differences between the three fertilizer products, the differences are not statistically significant.

Table 2. Sunflower grain yields at different conditions of application and complex fertilizer products under different climatic conditions in South-East Romania

Experimental factors		Yields obtained in 2022			Yields obtained in 2023		
Application method	Complex fertilizer product	Yield (kg/ha)	Differences to control		Yield (kg/ha)	Differences to control	
			kg/ha	%		kg/ha	%
Surface broadcast + incorporation	NPK 20-20-0	1777	-96	-5	2014	-67	-3.2
	Duofertil Eurocereal 34	2574	701 *	37	2768	687 *	33.0
	DAP (18-46-0)	1583	-290	-15	1779	-302	-14.5
Banded with sowing	NPK 20-20-0	1610	-263	-14	1807	-274	-13.2
	Duofertil Eurocereal 34	2033	160	9	2284	203	9.8
	DAP (18-46-0)	1661	-212	-11	1836	-245	-11.8
Average		*1873*	*Control*	-	*2081*	*Control*	-
		$LSD_{5\%}$ = 697.76 kg/ha $LSD_{1\%}$ = 978.27 kg/ha $LSD_{0.1\%}$ = 1382.71 kg/ha			$LSD_{5\%}$ = 676.62 kg/ha $LSD_{1\%}$ = 948.63 kg/ha $LSD_{0.1\%}$ = 1340.82 kg/ha		

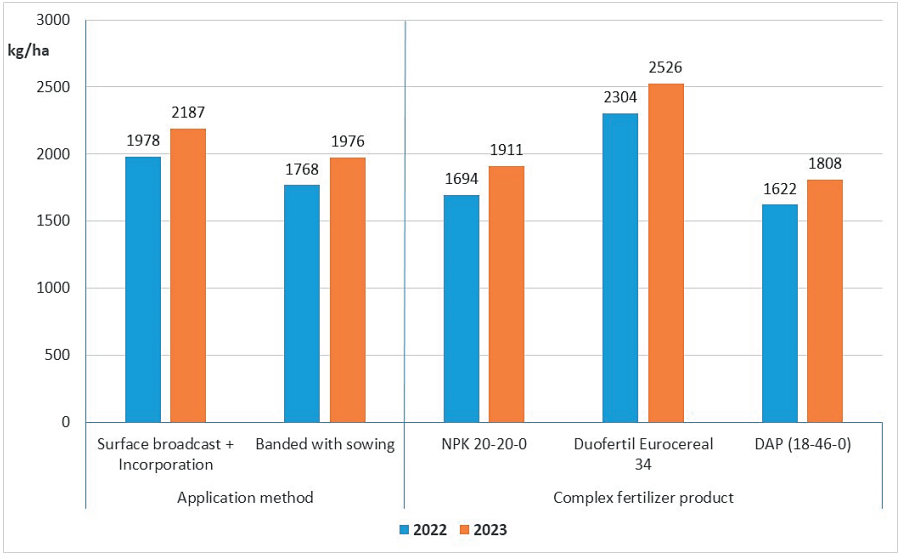

Figure 1. Yield average values at different conditions of application and complex fertilizer products under different climatic conditions in South-East Romania

Regarding the sunflower plant height, the highest values (137.5 cm in 2022 and 147.0 cm in 2023) were determined by the complex fertilizer NPK 20-20-0 broadcasted and incorporated at the seedbed preparation, with a difference statistically significant in 2023 compared to the average value of all the experimental variants (Table 3). If in the case of the application method of surface broadcast with incorporation at seedbed preparation the highest plant heights were determined by the complex fertilizer NPK 20-20-0 in both experimental years, in the case of application method of banded with sowing the highest plant heights were determined by the complex fertilizer Duofertil Eurocereal 34.

The smallest plant height values were registered in both experimental years in the case of complex fertilizer DAP (18-46-0) of the application method of surface broadcast with incorporation at seedbed preparation.

The better water supply of the sunflower plants through the high rainfall determined higher values of the plant height in 2023 (135.6 cm in average) compared to 2022 (131.8 cm in average) (Table 3). In fact, all the average values of the plant height reported to the application method of the fertilizers or the complex fertilizer products are higher in 2023 than in 2022 (Figure 2).

Table 3. Sunflower plant height at different conditions of application and complex fertilizer products under different climatic conditions in South-East Romania

Experimental factors		Plant height in 2022			Plant height in 2023		
Application method	Complex fertilizer product	Plant height (cm)	Differences to control		Plant height (cm)	Differences to control	
			cm	%		cm	%
Surface broadcast + incorporation	NPK 20-20-0	137.5	5.7	4.3	147.0	11.4 *	8.4
	Duofertil Eurocereal 34	132.9	1.1	0.8	135.8	0.2	0.1
	DAP (18-46-0)	125.7	-6.1	-4.6	128.5	-7.1	-5.2
Banded with sowing	NPK 20-20-0	128.7	-3.1	-2.4	130.6	-5	-3.7
	Duofertil Eurocereal 34	133.7	1.9	1.4	136.7	1.1	0.8
	DAP (18-46-0)	132.1	0.3	0.2	135.1	-0.5	-0.4
Average		*131.8*	*Control*	-	*135.6*	*Control*	-
		$LSD_{5\%}$ = 8.01 cm $LSD_{1\%}$ = 11.22 cm $LSD_{0.1\%}$ = 15.86 cm			$LSD_{5\%}$ = 9.37 cm $LSD_{1\%}$ = 13.15 cm $LSD_{0.1\%}$ = 18.58 cm		

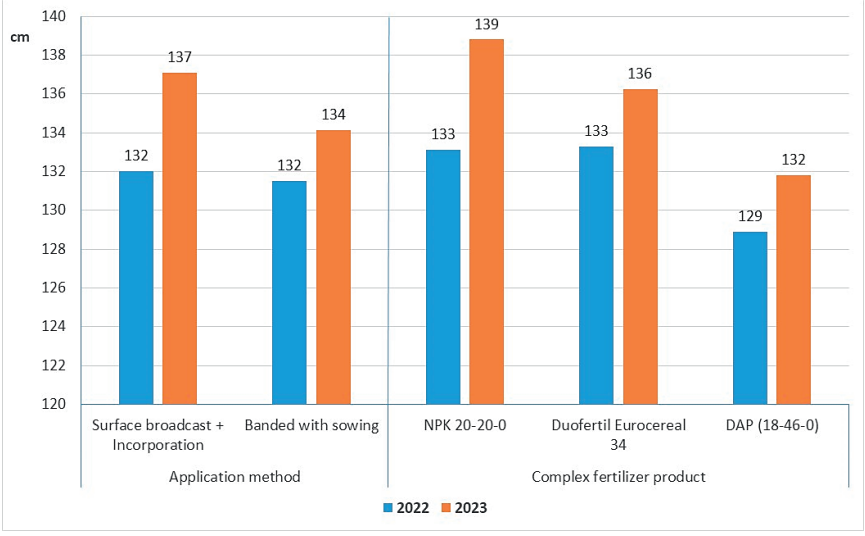

Figure 2. Plant height average values at different conditions of application and complex fertilizer products under different climatic conditions in South-East Romania

Regarding the two application methods of the experimented fertilizers, if in 2022 there are no differences of the average values of the plant height, in 2023 the average value of the plant height is higher in the case of the application method of surface broadcast with incorporation at seedbed preparation.

Regarding the three complex fertilizer products, the highest average plant height was register in 2022 in the case of complex fertilizers NPK 20-20-0 and Duofertil Eurocereal 34 (133 cm), but in 2023 the complex fertilizers NPK 20-20-0 with a value of 139 cm of the plant height proved to be the best.

CONCLUSIONS

Following the research carried out in South-Est Romania in 2022 and 2023, the complex fertilizer Duofertil Eurocereal 34 proved to assure the highest grain yields especially when it was broadcasted and incorporated at the seedbed preparation. Even there are differences between the three experimented fertilizer products, the differences are not statistically significant.

Surface broadcast of the experimented fertilizers followed by their incorporation through the seedbed preparation proved to be more efficient then the banded fertilizer application with sowing regardless of the climatic conditions of the experimented year.

The better water supply of sunflower plants gives them the possibility to use in more efficient way the available nutrients, this resulting in higher grain yields and plant heights.

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