SUNFLOWER YIELD AT DIFFERENT NITROGEN RATES AND FERTILIZER PRODUCTS

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Abstract

Current climatic conditions, increasing concern of the entire society regarding the environmental protection, as well as regarding the access to save and safety food, to which it is added the increasingly cost of nitrogen fertilizers require farmers to optimize nitrogen fertilization according to the specific growing conditions of their crops. Choosing the right fertilizer product, rate and time of application are essential decisions for farmers. In this context, the purpose of this paper is to present the results obtained regarding sunflower yield under different nitrogen fertilization conditions as rate and fertilizer product under the specific growing conditions of South-Est Romania. In this sense, field experiments were performed in South-East Romania, respectively in Dobrogea region, under rainfed conditions in the years 2022 and 2023. The experimental factors were the following: Factor A – Nitrogen rate, with 3 gradations, respectively 60 kg/ha, 80 kg/ha, 100 kg/ha; Factor B – Nitrogen fertilizer, with 4 gradations, namely Classic Urea, Airtek Urea, Ammonium Sulphate, Sulfammo 25 MPPA DUO. The obtained results obtained under water deficit conditions drew attention to the positive effects of Classical Urea on the sunflower grain yield. It resulted that the best fertilizer option is the nitrogen rate of 60 kg/ha incorporated at seedbed preparation.

Key words: sunflower, nitrogen, fertilizer, rate, yield

Sunflower has uses in human nutrition and animal feed, industrial and energy uses, to which are added a number of specific uses (Ion V., 2021).

Sunflower is grown mainly for oil, which is a good quality edible oil with a pleasant color, taste and smell. In terms of caloric value and degree of assimilation by the body, sunflower oil is among the best vegetable oils (Petcu G., Petcu E., 2008). Unshelled sunflower seeds, but mostly the cakes resulting after oil extraction can be used in animal feed. The cakes are primarily used as a source of protein (Bîlteanu G., 2001).

Sunflower is cultivated globally, but it is mainly cultivated in Europe, especially in the Black Sea region. In Romania, in recent years there was cultivated with sunflower over 1 million ha, one of the explanation for this large surface being the farmers orientation towards crops which better tolerate the increasingly frequent droughts of recent years.

The sunflower sector has managed to maintain its competitiveness through continuous innovation in genetics, cultivation practices and value-added research that has led to greater market segmentation (Pilorgé E., 2020). Climate change has, however, led to a significant decrease in sunflower production (Babec B. *et al*, 2021). Agro-meteorological conditions have a significant impact on yield (Nedealcov M. *et al*, 2016). In its traditional production areas, sunflower crop will be exposed to major climate change and potentially impacted by water and temperature stresses (Prodan T. (P.) *et al*, 2021).

The use of fertilizers is essential for plant growth (Negi P. *et al*, 2022). In the modern agriculture, the importance of using chemical fertilizers is undeniable (Leonte A. *et al*, 2023). But it is necessary to optimize the fertilizer use to meet the yielding and environment issues. Optimizing fertilizers leads to the achievement of economic and environmental goals in sustainable agriculture (Mehrparvar M. *et al*, 2021).

Fertilization is one of the major factors that could increase sunflower yield (Shoghi-Kalkhoran S. *et al*, 2013). Nutrient management is one of the main factors that influence sunflower achene yield, achene oil, and fatty acid contents (Mahmood H.N., 2021), its importance being increasing in the actual climate change.

Nitrogen (N) is one of the most important mineral nutrients because of its numerous effects on plant growth and yield (Ahmad R. *et al*, 2014). Nitrogen is one of the major nutrients that enhance the metabolic processes that based on protein,

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leads to increases in vegetative, reproductive growth and yield of the crop (Abd El-Rahman L. A. *et al*, 2016).

Nitrogen is the major nutrient required by sunflowers, and has the greatest impact on seed size, leaf size and number of leaves, test weight and yield (Toosi A.F., Azizi M., 2014). 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 I. *et al*, 2023). Two main approaches can be undertaken to enhance nitrogen use efficiency: increasing the use of N during crop growing season and decreasing the losses of N by applying optimum doses (Khanzada A. *et al*, 2016).

The large variation in the response of sunflower to nitrogen fertilization indicates the need for studies to better adjust the optimum levels of this nutrient for production conditions (Coêlho, E.D.S. *et al*, 2022). Choosing the right fertilizer product, rate and time of application are essential decisions for farmers. In this context, the purpose of this paper is to present the results obtained regarding sunflower yield under different nitrogen fertilization conditions as rate and fertilizer product under the specific growing conditions of South-Est Romania.

MATERIAL AND METHOD

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 3 x 4 with the following experimental factors:

- Factor A - Nitrogen rate:
  - a1 = 60 kg/ha nitrogen;
  - a2 = 80 kg/ha nitrogen;
  - a3 = 100 kg/ha nitrogen;
- Factor B - Nitrogen fertilizer:
  - b1 = Classic Urea;
  - b2 = Airtek Urea;
  - b3 = Ammonium Sulphate;
  - b4 = Sulfammo 25 MPPA DUO;

The basic fertilization was done with the product DAP 18-46-0 in a dose of 150 kg/ha, a product that provides 27 kg/ha of nitrogen and 69 kg/ha of P_2O_5.

The nitrogen difference up to the studied quantity was applied from each studied product at the preparation of the seedbed.

Classic Urea ($(NH_2)_2CO$) is a product with a high nitrogen content (46% nitrogen) which gives urea a priority place in agricultural use, representing the most economical source of nitrogen available. This is produced by Azomureș company.

Airtek Urea is produced by Belor in partnership with BASF who developed the new range of Airtek fertilizers that use the urease inhibitor Limus. It is a formula that contains 46% nitrogen completely inhibited with Limus. By using this product, the losses of nitrogen through volatilization are completely canceled and the availability of nitrogen is regulated for the efficient increase of fertilization.

Ammonium Sulphate is an inorganic compound with the chemical formula $(NH_4)_2SO_4$. This has a wide range of commercial uses, being an important soil fertilizer. The commercial product contains 21% nitrogen from the ammonium cation and 24% sulfur from the sulfate anion.

Sulfammo 25 MPPA DUO is a product with 25% total nitrogen (N), of which 18% ammonia nitrogen (NH_4^+) and 7% nitric nitrogen (NO_3^-), 2% magnesium oxide (MgO), and 31% sulfuric anhydride (SO3) soluble in water. The product contains MPPA DUO, which is the optimal combination of 2 active compounds: MPPA (Activated Poly-Phenolic Molecules) extracted from organic acids, responsible for the protection of nutrients in the product and the mobilization of nutrients from the soil; XCK (Plant extract) containing a phytohormonal precursor, stimulator of the microbial activity in the rhizosphere and of the metabolic processes of plant growth and development, especially of the roots and absorbing peripheries. Sulfammo 25 MPPA DUO is created by the research department of Timac Agro.

Each experimental variant had a size of 67.2 m^2 consisting of 12 rows of sunflower plants with 70 cm between rows resulting in a width of 8.4 m and a length of 8 m along the rows.

The previous crop was maize. Tillage in the experimental field consisted of harrowing after harvesting the previous crop, and in October plowing was carried out at a depth of 20 cm. The plowing was followed in the fall by harrowing and in the spring the seedbed preparation was carried out before sowing with a cultivator.

Sowing was carried out on April 9, 2022 and May 3, 2023. The ensured plant density was 64,000 plants per hectare.

The sunflower hybrid used in the research was SY Onestar CLP, a hybrid with exceptional production potential, adaptable and stable under different growing conditions.

Weed control was achieved by applying the herbicide Pulsar 40 (Imazamox 40 g/l) in a rate of 1.2 l/ha in the growth stage of 6 leaves of sunflower plants.

For controling sunflower diseases, the fungicide Pictor Active (Boscalid 150 g/l and Pyraclostrobin 250 g/l) was applied in a rate of 1 l/ha in the growth stage of 10 leaves of sunflower plants.

The results that are presented in the present paper are with respect to the grain yield (kg/ha)

reported at 9% moisture content. The calculation and interpretation of the results were made based on the analysis of variance

The geographical coordinates (44°59'15.4"N 28°22'08.0"E) 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 10.7 ºC.

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 than the year 2022 with 16.8ºC.

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***

Regarding the rainfall registered during the vegetation period of the sunflower plants, the year 2022 with 162 mm was drier than the year 2023 with 250 mm. In the year 2023, after a drought month March with 8 mm rainfall, there followed a rainy month April with 125 mm. As a consequence, in 2023 the sowing was significantly delayed compared to the usual sowing period for the studied area, which is between the end of March and the beginning of April. Thus, in 2023 the sowing was performed on May 3. In both experimental years the month July but especially August were characterized by a small amount of rainfall.

In the studied area, the specific soil is carbonate chernozem with 2.5% humus content and pH of 7.8-8.1.

RESULTS AND DISCUSSIONS

Because of the climate, which is constantly changing, in general but especially when it comes to the South-East of Romania, which is one of the poorest areas in the country in terms of precipitation, it is essential to adapt and find the best and most effective solutions of fertilization.

In the research carried out, fertilization with Classic Urea in a rate of 60 kg/ha of nitrogen, incorporated in the soil during the preparation of the seedbed, ensured the highest yields in both experimental years, respectively 2044 kg/ha in 2022 and 2310 kg/ha in 2023 (*table 2*). Also in both experimental years, at the rate of 80 kg/ha of nitrogen, the best results were registered in the case of Airtek Urea, while at the rate of 100 kg/ha of nitrogen, the best results were registered in the case of Sulfammo 25 MPPA DUO.

In the year 2022, increasing the amount of nitrogen to 80 kg/ha had a negative influence on grain yield, compared to control variant with a difference negative distinctly significant (-686 kg/ha) in the variant fertilized with Classic Urea and with a difference negative significant in the variant fertilized with Sulfammo 25 MPPA DUO (-533 kg/ha). The same situation can be found in 2023, when the grain yield difference in the case of the two fertilizers mentioned above was for both of them negative significant.

Table 2

Sunflower grain yield at different nitrogen rates and nitrogen fertilizers in different climatic conditions in South-East of 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)	(%)
60	Classic Urea	2044	Control	100	2310	Control	100
	Airtek Urea	1539	-505 °	- 25	1807	-503 °	-22
	Ammonium Sulphate	1561	-483 °	-24	1821	-489	-21
	Sulfammo 25 MPPA DUO	1868	-176	-9	1868	-442	-19
80	Classic Urea	1358	-686 °°	-34	1781	-529 °	-23
	Airtek Urea	1914	-130	-6	1914	-396	-17
	Ammonium Sulphate	1635	-409	20	1896	-414	-18
	Sulfammo 25 MPPA DUO	1511	-533 °	-26	1768	-542 °	-24
100	Classic Urea	1855	-189	-9	2110	-200	-9
	Airtek Urea	1862	-182	-9	2149	-161	-7
	Ammonium Sulphate	1644	-400	-20	1905	-405	-18
	Sulfammo 25 MPPA DUO	2003	-41	-2	2281	-29	-1
Average		*1733*	-	-	*1968*	-	-
		$LSD_{5\%}$ = 473.94 kg $LSD_{1\%}$ = 642.25 kg $LSD_{0.1\%}$ = 859.94 kg			$LSD_{5\%}$ = 493.62 kg $LSD_{1\%}$ = 668.93 kg $LSD_{0.1\%}$ = 895.65 kg		

The average yield obtained in 2023 is higher than in 2022, respectively 1968 kg/ha in 2023 and 1733 kg/ha in 2022, this being the result of higher precipitation in 2023 during the vegetation period of sunflower plants, which have a total of 250 mm, compared to 162 mm in 2022. Therefore, all average yields related to either nitrogen rate or nitrogen product used are higher in 2023 than in 2022. Basically, a better water supply to the sunflower plants gives them the opportunity to use the available nutrients in a more efficient way.

Analyzing the grain yield average values per nitrogen rate, the highest grain yields were obtained at 100 kg/ha of nitrogen (1841 kg/ha in 2022 and 2112 kg/ha in 2023), but with a yield increase compared to the rate of 60 kg/ha of only 5% in 2022, respectively 88 kg/ha, and of 8% in 2023, respectively 160 kg/ha (*table 3*). The grain yield increase obtained at 100 kg/ha of nitrogen compared to the nitrogen rate of 60 kg/ha do not obviously cover the cost of the extra 40 kg/ha of nitrogen.

Table 3

Sunflower grain yields as average values at different nitrogen rates in different climatic conditions in South-East of Romania

Experimental factor	Yields obtained in 2022			Yields obtained in 2023		
Nitrogen Rate	Yield	Differences to control		Yield	Differences to control	
(kg/ha)	(kg/ha)	kg/ha	%	(kg/ha)	kg/ha	%
60	1753	Control	100	1952	Control	100
80	1604	-149	-8	1840	-112	-6
100	1841	+88	+5	2112	+160	+8
	$LSD_{5\%}$ = 510.96 kg/ha $LSD_{1\%}$ = 685.64 kg/ha $LSD_{0.1\%}$ = 903.87 kg/ha			$LSD_{5\%}$ = 487.16 kg/ha $LSD_{1\%}$ = 653.71 kg/ha $LSD_{0.1\%}$ = 861.78kg/ha		

The obtained results are the effect of water deficit registered in both experimental years, which limit the plant use of the available nutrients. In fact, the reduced nutrient availability is one of the most important factors limiting plant growth under drought (Canavar Ö., Kaptan M.A., 2014).

In both experimental years, the smallest grain yields were registered in the case of the nitrogen rate of 80 kg/ha (-149 kg/ha in 2022 and -112 kg/ha in 2023 compared to control variant). It has to be mentioned that compared to control variant which was the nitrogen rate of 60 kg/ha, the differences registered at the nitrogen rates of 80 kg/ha and 100 kg/ha are not statistically significant (*table 3*).

As average values of the grain yield obtained for different nitrogen products, we notice that there are no differences statistically significant compared to control variant represented by Classic Urea for any of them (*table 4*). In 2022, the fertilizer product with the highest grain yield is Sulfammo 25 MPPA DUO, respectively 1794 kg/ha, but only with a grain yield increase of 42 kg/ha compared to control variant. In 2023, compared to control variant, all the other fertilizer products registered negative differences. In both experimental years, the smallest average grain yields were registered in the case of the fertilizer product Ammonium Sulphate.

Table 4

Sunflower grain yields as average values with different nitrogen fertilizers in different climatic conditions in South-East of Romania

Experimental factor	Yields obtained in 2022			Yields obtained in 2023		
Nitrogen Fertilizer	Yield	Differences to control		Yield	Differences to control	
	(kg/ha)	kg/ha	%	(kg/ha)	kg/ha	%
Classic Urea	1752	Control	-	2067	Control	-
Airtek Urea	1771	+19	+1	1957	-111	-5
Ammonium Sulphate	1613	-138	-8	1874	-193	-9
Sulfammo 25 MPPA DUO	1794	+42	+2	1973	-95	-5
	$LSD_{5\%}$ = 535.52 kg/ha $LSD_{1\%}$ = 721.20 kg/ha $LSD_{0.1\%}$ = 956.18 kg/ha			$LSD_{5\%}$ = 521.41 kg/ha $LSD_{1\%}$ = 702.19 kg/ha $LSD_{0.1\%}$ = 930.98 kg/ha		

CONCLUSIONS

Following the research carried out in South-Est Romania in 2022 and 2023 under water deficit conditions it resulted that the best fertilizer option is the nitrogen rate of 60 kg/ha assured through the Classic Urea fertilizer product incorporated at seedbed preparation. Under the experimented conditions, practically there were not registered significant differences in grain yield as average values between the nitrogen rates and nitrogen fertilizer products.

REFERENCES

Abd El-Rahman L.A., Sayed D.A., Ewais M.A., 2016 - *Seed yield and quality of sunflower (Helianthus annuus L.) as influenced by integrated mineral and organic nitrogen fertilization systems*. Journal of Soil Sciences and Agricultural Engineering, 7(1):53-63.

Ahmad R., Waraich E.A., Ashraf M.Y., Ahmad S., Aziz T., 2014 - *Does nitrogen fertilization enhance drought tolerance in sunflower? A review*. Journal of Plant Nutrition, 37(6):942–963.

Babec, B., Šeremešić S., Hladni N., Ćuk N., Stanisavljević D., Rajković M., 2021 - *Potential of Sunflower-Legume Intercropping: A Way Forward in Sustainable Production of Sunflower in Temperate Climatic conditions*. Agronomy, 11:2381.

Bîlteanu G., 2001 - *Fitotehnie, vol. 2 – Oleifere, textile, tuberculifere şi rădăcinoase, tutun, hamei, medicinale*, Editura Ceres, Bucureşti.

Canavar Ö., Kaptan M.A., 2014 - *Changes in macro and micro plant nutrients of sunflower (Helianthus annuus L.) under drought stress*. Scientific Papers. Series A. Agronomy, 57:136-139.

Coêlho E.d.S., Souza A.R.E.d., Lins H.A., Santos M.G.d., Freitas Souza M.d., Tartaglia F.d.L., de Oliveira A.K.S., Lopes W.d.A.R., Silveira, L.M., Mendonça V. et al., 2022 - *Efficiency of Nitrogen Use in Sunflower*. Plants, 11:2390.

Gerassimova I., Katsarova A., Benkova M., Nenova L., Petkova Z., 2023 - *Influence of fertilization on uptake of macroelements with sunflower biomass*. Journal of Central European Agriculture, 24(1):236-244.

Ion V., 2021 - *Floarea-soarelui*. In: Ion V., Băşa A.G., (eds), *Fitotehnie – Plante oleaginoase*. Capitolul 2, pp. 22-207, Editura Ex Terra Aurum, Bucureşti.

Khanzada A., Ansari M.A., Chang B.H., Rajput A., Magsi F.H., Ali U., 2016 - *Evaluating Right Timing and Splitting Nitrogen Application Rates for Enhanced Growth and Yield of Sunflower*. European Academic Research, 4(7):5986-6007.

Leonte A., Isticioaia S.F., Pintilie P., Druțu A.C., Enea A., Eşanu S., 2023 - *Research on the influence of different doses of nitrogen and phosphorus on yield and quality indices on corn seeds, under pedoclimatic conditions at A.R.D.S. Secuieni*. Scientific Papers. Series A. Agronomy, LXVI(2):310-315.

Mahmood H.N., 2021 - *Efficacy of various NPK application methods on the yield of different sunflower (Helianthus annuus L.) genotypes grown during spring seasons*. Applied Ecology and Environmental Research, 19(1):491–505.

Mehrparvar M., Rokhzadi A., Mohammadi K., 2021 - *Reduced N Application Rate in Sunflower Production Through Supplying P and K Need and Dense-Planting: A Modeling and Optimization Approach by RSM*. Journal of Soil Science and Plant Nutrition, 21(12).

Nedealcov M., Duca M., Cojocari R., Raileanu V., Clapco S., 2016 - *Impactul perioadelor uscate asupra productivităţii culturii de floarea-soarelui*. *Biodiversitatea în contextul schimbărilor climatice, 25 noiembrie 2016,* Chișinău, Republica Moldova: Universitatea Academiei de Ştiinţe a Moldovei, Ediţia a 1-a, pp. 192-197.

Negi P., Thakur R., Manral K., Tomar K., Rawat B.S., Ramola B., Ahma W., 2022 - Coated Controlled-Release Fertilizers: Potential Solution for Sustainable Agriculture. Nature Environment and Pollution Technology, 21(4):1739-1745.

Petcu G., Petcu E., 2008 - *Ghid tehnologic pentru grâu, porumb, floarea-soarelui*. Editura Domino.

Pilorgé E., 2020 - *Sunflower in the Global Vegetable Oil System: Situation, Specificities and Perspectives*. OCL, 27(34). Available online: https://www.ocl-journal.org/articles/ocl/full_html/2020/01/ocl200028s/ocl200028s.html

Prodan T. (P.), Joita-Pacureanu M., Ion V., Duca M., Dan M., Anton G.F., Rîşnoveanu L., Lipşa F.D., Florea M.A., Bran A., Sava E., Ulea E., 2021 - *Sunflower genotypes with high tolerance to drought and extreme temperatures, having good resistance to some specific diseases*. Lucrări Ştiinţifice, seria Agronomie, 64(2):125-130.

Shoghi-Kalkhoran S., Ghalavand A., Modarres-Sanavy S.A.M., Mokhtassi-Bidgoli A., Akbari P., 2013 - *Integrated Fertilization Systems Enhance Quality and Yield of Sunflower (Helianthus annuus L.)*. Journal of Agricultural Science & Technology, 15:1343–1352.

Toosi A.F., Azizi M., 2014 - *Effect of different sources of nitrogen fertilizer on yield & yield components of sunflower (Helianthus annuus L.)*. Scientific Papers. Series A. Agronomy, LVII:364-366.