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NITROGEN RATE AND FERTILIZER TYPE EFFECTS ON OILSEED RAPE GRAIN YIELD

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Abstract. *Oilseed rape (Brassica napus L.) is an oil crop highly demanding for nutrients, especially nitrogen. In the current global context, nitrogen has to be used by farmers in the most efficient way, the rate having to be correlated with the environmental conditions and the yield objectives of the farmer, and the most effective nitrogen fertilizer having to be used. Starting from these ideas, the aim of the performed research was to identify the effects of nitrogen rates on grain yield at winter oilseed rape by using Urea and Urea NG as nitrogen fertilizer in the specific growing conditions of South Romania. In this respect, research was performed in field conditions in South Romania in the years 2023, 2024, and 2025, this having the following experimental factors: Factor A. Nitrogen fertilizer type (a1- no nitrogen fertilizer used - control variant; a2- Urea; a3- Urea NG); Factor B. Nitrogen rate (b1- 100 kg/ha; b2- 130 kg/ha; b3- 160 kg/ha; b4- 190 kg/ha). The field experiment was organized as subdivided macro-plots with 3 replications, each replication having 0.33 ha. For Urea fertilizer, the nitrogen rate of 130 kg/ha (60 kg applied in autumn and 70 kg applied early in the spring) under less favourable climatic conditions, and the nitrogen rate of 160 kg/ha (60 kg applied in autumn and 100 kg applied early in the spring) under favourable climatic conditions were highlighted. For Urea NG fertilizer, the nitrogen rate of 160 kg/ha was highlighted regardless the climatic conditions of the year. Nitrogen is utilized by the oilseed rape plants according to the climatic conditions of the year: the better the climatic conditions of the year, the better the plants use the nitrogen, and higher grain yields are obtained at higher nitrogen rates.*

Keywords*: winter oilseed rape, fertilization, nitrogen rate, nitrogen fertilizer, grain yield.*

INTRODUCTION

Fertilizers are essential for providing the necessary nutrients and promoting plant growth (Zaib et al., 2023), in the modern agriculture, the importance of using chemical fertilizers being undeniable (Leonte et al., 2023). The effective use of inorganic fertilizers has been responsible for increased food production more than any other input (Penuelas et al., 2023). The invention and up-scaling of the Haber-Bosch process for manufacturing mineral nitrogen (N) fertilizers and the application of these fertilizers to modern agriculture have been crucial in achieving the high yield levels that are possible in today's agricultural production (Bouchet et al., 2016). But the intensive use of synthetic fertilizers in conventional agriculture has led to significant environmental challenges, including water pollution, greenhouse gas emissions, and soil degradation, while contributing to diminishing returns in crop productivity (Minea et al., 2025).

Current climatic conditions, increasing concern of the entire society regarding the environmental protection, as well as regarding the access to safety food, and the increasingly cost of nitrogen fertilizers in the actual global energy context require farmers to optimize nitrogen fertilization according to the specific growing conditions of their crops (Jenaru and Ion, 2024). The use of slow-release and controlled-release fertilizers is aimed at providing a

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step towards better N management (Haraga et al., 2025). Slow-release nitrogen fertilizer can potentially increase crop production, improve NUE, reduce leaching and denitrification in the soil, and therefore significantly reduce nitrogen loss (Bahar et al., 2019; Feng et al., 2021).

Nitrogen (N) is one of the most important mineral nutrients because of its numerous effects on plant growth and yield (Ahmad et al., 2014; Béreš et al., 2019). Among all nutrients, nitrogen is the nutrient most limiting crop production in all areas of the world and is generally applied to soil in the largest quantity (Penuelas et al., 2023).

Oilseed rape (*Brassica napus* L.) is one of many crops with high nutritional requirements (Mocanu et al., 2011), particularly for nitrogen (N) and sulphur (S) (Jarecki et al., 2024). Applying nitrogen is an important way of ensuring a strong and stable yield (Zhu et al., 2023). Nitrogen has a strong effect on seed yield and quality at oilseed rape, the nitrogen demand being considerably higher than that of cereals (Narits, 2010). Practically, seed yield and protein content increase in response to increasing nitrogen application (Bilsborrow et al., 1993). Generally, at oilseed rape, there is a positive correlation between yield and dose of nitrogen and there is a negative correlation between oil content and dose of nitrogen (Varényiová and Ducsay, 2016).

Choosing the correct rate, source, and timing of nitrogen fertilizer application is an important aspect of successful rapeseed production (Yahbi et al., 2022). The rate of N fertilizer applied in spring is decisive for the final yield of oilseed rape seeds, N fertilization having to be managed as to (i) avoid sub-optimal N nutrition, which could negatively affect final seed yield, and (ii) avoid supra-optimal N nutrition, which could, in turn, negatively affect seed quality and create a big risk of N leaching (Barłóg and Grzebisz, 2004).

At oilseed rape, urea tends to increase N partitioning in the shoot toward generative organs, while total N accumulation in the shoot at the end of the vegetation period is not necessarily affected (Heuermann et al., 2021). In recent times, the utilization of urea-modified fertilizers has emerged as a crucial factor in improving the availability of mineral nitrogen in the soil, numerous studies highlighting the beneficial impact of urea-controlled or slow-release compounds on crop productivity, but there is still a requirement for more extensive investigations to better understand the effects of these compounds (Swify et al., 2024).

The aim of the performed research was to identify the effects of nitrogen rates on grain yield at winter oilseed rape by using Urea and Urea NG as nitrogen fertilizer in the specific growing conditions of South Romania..

MATERIAL AND METHODS

Research was performed in field conditions in the specific growing conditions of South Romania (about 30 km northeast from Bucharest), in the years 2023, 2024, and 2025,

The field experiment was organized as subdivided macro-plots with 3 replications, having two experimental factors, respectively:

- Factor A: Nitrogen fertilizer type, with the following variants:
  - a1 – no nitrogen fertilizer used, which represents the control variant;
  - a2 – Urea;
  - a3 – Urea NG.
- Factor B: Nitrogen rate, with the following variants:
  - b1 – 100 kg/ha;
  - b2 – 130 kg/ha;
  - b3 – 160 kg/ha;
  - b4 – 190 kg/ha.

Urea $(NH_2)_2CO$) is a fertilizer with a high nitrogen content (46% nitrogen), representing the most economical source of nitrogen available. Urea NG is a fertilizer with the same nitrogen content (46%) as Urea, but it has its grains coated with a Neem extract (N-Guard Oil) film which provides a slow-release of nitrogen, in this way allowing plants to use the nitrogen gradually over a longer period of time and diminishing the nitrogen losses.

Before seedbed preparation in autumn, 300 kg/ha of complex fertilizer 20:20:0 + 13S was applied for all the experimental variants, this assuring 60 kg/ha of nitrogen, 60 kg/ha of phosphorus, and 39 kg/ha of sulphur.

Early in the spring, for each experimental variant, according to the nitrogen rate, Urea and Urea NG were applied starting from the nitrogen rate of 60 kg/ha applied in autumn, respectively early in the spring, there were applied 40 kg of nitrogen for the rate of 100 kg/ha, 70 kg of nitrogen for the rate of 130 kg/ha, 100 kg of nitrogen for the rate of 160 kg/ha, and 130 kg of nitrogen for the rate of 190 kg/ha. The control variant with no nitrogen fertilizer applied in the spring received the 60 kg/ha of nitrogen applied in autumn as complex fertilizer 20:20:0 + 13S.

The field experiment was organized as macro plots having 0.333 ha for each replication, which means 1 ha for each experimental variant and 9 ha in total.

The oilseed rape hybrid which was used in the experimental field was PT298, which is a mid-early hybrid with a high yielding potential. The sowing was performed as follows: on the 20th of August in 2022; on the 11th of September in 2023; on the 4th of September in 2024. In all experimental years, the sowing density was 50 germinating seeds per square meter.

The preceding crop was winter wheat in all experimental years. Tillage consisted of a passage after harvesting the preceding crop with the cultivator Tiger 3 MT at a depth of 30 cm. Then, a passage with a cultivator was performed before sowing for seedbed preparation.

In autumn, a herbicide was applied for controlling the monocotyledonous weeds and an insecticide was applied for controlling the pests.

In spring, in the years 2023 and 2024, one herbicide was applied for controlling monocotyledonous weeds and one herbicide for controlling dicotyledonous weeds. Also, for controlling the pests in the spring, three insecticides were applied in 2023 and four insecticides in 2024 and 2025. For controlling diseases in the spring, two fungicides were applied in 2023 and 2024 and three fungicides were applied in 2025.

All the macro plots on replications for each experimental variant were harvested separately with a harvester machine and the grains were weighed. The moisture content of the seeds was determined with the help of a Portable Moisture Analyser. The yield was calculated per hectare and expressed in kg reported at 9% moisture content.

The field experiment was located on a cambic chernozem soil. According to the physical plot where the field experiment was located each year, the soil characteristics are the following: in 2023, pH was 5.77, the organic matter content was 2.25%, and the nitrogen index was 1.82; in 2024, pH was 5.9, the organic matter content was 2.57%, and the nitrogen index was 2.07; in 2025, pH was 5.96, the organic matter content was 2.65%, and the nitrogen index was 2.15.

Comparing the three experimental years from a climatic point of view, the most favourable for winter oilseed rape was the year 2025, with good rainfall in the previous autumn and a large amount of precipitation (130.3 mm) in May, respectively in the period of grain setting and filling. Second comes the year 2023 for climatic favourability, with a high amount of rainfall in April, May, and June and with not so high temperatures. The year 2024 was the least favourable from a climatic point of view for winter oilseed rape.

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RESULTS AND DISCUSSIONS

In all experimental years, compared to the control variant which received only 60 kg/ha of nitrogen in the autumn in the form of a complex fertilizer before seedbed preparation, all the experimental variants which received nitrogen in the spring, regardless of the applied rate and nitrogen fertilizer, registered positive differences (Table 1).

In the year 2023, the differences were statistically significant only for the rate of 130 kg/ha in the form of Urea and for the rate of 160 kg/ha in the form of Urea NG, but in this case, the difference was distinct significant (the difference compared to the control variant was 500 kg/ha for Urea NG at the nitrogen rate of 160 kg/ha and 360 kg/ha for Urea at the nitrogen rate of 130 kg/ha).

In the year 2024, the differences were statistically significant for high nitrogen rates (160 and 190 kg/ha) for both nitrogen fertilizers (Urea and Urea NG), but while the difference was distinct significant for Urea fertilizer, it was very significant for Urea NG fertilizer. As it was the case in the year 2023, also the nitrogen rate of 130 kg/ha in the form of Urea determined a statistically significant difference compared to control variant.

In the year 2025, all the experimental variants registered differences statistically significant compared to the control variant. But, while the differences were very significant for the nitrogen rates of 160 and 190 kg/ha for both nitrogen fertilizers (Urea and Urea NG) and for the nitrogen rate of 130 kg/ha in the case of Urea NG, the differences were distinct significant for the nitrogen rate of 130 kg/ha in the case of Urea, and the differences were just significant for the nitrogen rate of 100 kg/ha for both nitrogen fertilizers.

Table 1

Oilseed rape yield at different nitrogen rates and nitrogen fertilizer types

Experimental variants		2023		2024		2025		Coefficient of variation between years (%)
Nitrogen fertilizer	Nitrogen rate (kg/ha)	Yield (kg/ha)	Difference to control (kg/ha)	Yield (kg/ha)	Difference to control (kg/ha)	Yield (kg/ha)	Difference to control (kg/ha)	
Control variant		3420	0	2640	0	3690	0	13.70
Urea	100	3480	60	2880	240	4080	390 *	14.08
	130	3780	360 *	2940	300 *	4260	570 **	14.91
	160	3430	10	2990	350 **	4530	840***	17.74
	190	3540	120	3090	450 **	4560	870***	16.49
Urea NG	100	3660	240	2850	210	4140	450 *	15.00
	130	3660	240	2880	240	4440	750***	17.40
	160	3920	500 **	3270	630 ***	5130	1440 ***	18.77
	190	3600	180	3360	720 ***	5140	1450 ***	19.55
$DL_{5\%}$			*315.22*		*255.21*		*384.48*	
$DL_{1\%}$			*431.80*		*349.59*		*526.67*	
$DL_{0.1\%}$			*588.44*		*476.41*		*717.72*	

All the experimental variants registered high values (higher than 10%) for the coefficient of variation between years (Table 1). The smallest values of the coefficient of variation were registered for the control variant, while the highest values were registered for the high nitrogen rates (160 and 190 kg/ha), especially for the Urea NG fertilizer, which means in this case a higher dependence on the climatic conditions of the year. Anyway, compared to

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the control variant, the application of nitrogen in the spring determined a higher variation of the grain yield from year to year depending on the climatic conditions, which means the nitrogen is put into value by the plants according to the climatic conditions. Zhao et al. (2023) also found that the effects of N application on winter oilseed rape are sensitive to environmental factors.

In the case of using Urea as nitrogen fertilizer, regardless of the nitrogen rate, the highest grain yields were obtained in the year 2025, which was the most favourable form a climatic point of view, and the smallest grain yields were obtained in the year 2024, which was the least favourable form a climatic point of view (Figure 1). Regarding the nitrogen rate, the highest grain yields were obtained in the years 2025 (4560 kg/ha) and 2024 (3090 kg/ha) at 190 kg/ha, but with small differences compared to the grain yield registered at the nitrogen rate of 160 kg/ha in 2025 (30 kg/ha difference) and 2024 (100 kg/ha difference), moreover in the year 2024 also with a small difference for the nitrogen rate of 130 kg/ha (150 kg/ha difference). As regarding the year 2023, the highest grain yield (3780 kg/ha) was obtained at the nitrogen rate of 130 kg/ha, in this year the dispersion coefficient having the smallest value (R^2=0.3447).

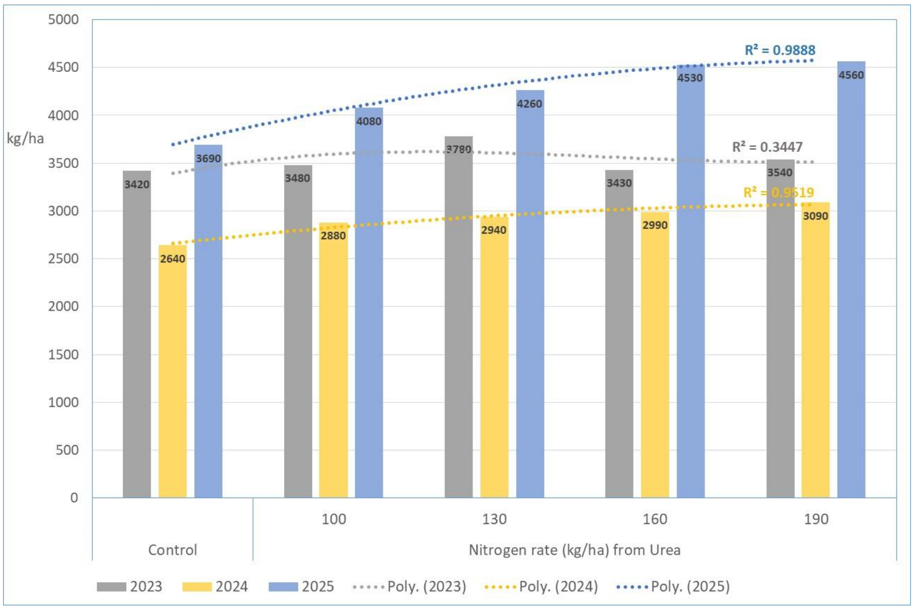

Figure 1. Oilseed rape yield at different nitrogen rates under the form of Urea (2023-2025 years)

Also in the case of using Urea NG as nitrogen fertilizer, regardless of the nitrogen rate, the highest grain yields were obtained in the year 2025, which was the most favourable form a climatic point of view, and the smallest grain yields were obtained in the year 2024, which was the least favourable form a climatic point of view (Figure 2). Regarding the nitrogen rate, the highest grain yields were obtained in the years 2025 (5140 kg/ha) and 2024 (3360 kg/ha) at 190 kg/ha, but as in the case of Urea fertilizer again with small differences compared to the grain yield registered at the nitrogen rate of 160 kg/ha in 2025 (10 kg/ha difference) and 2024 (90 kg/ha difference). As for the year 2023, the highest grain yield (3920 kg/ha) was obtained at the nitrogen rate of 160 kg/ha, in this year the dispersion coefficient having the smallest value (R^2=0.7104).

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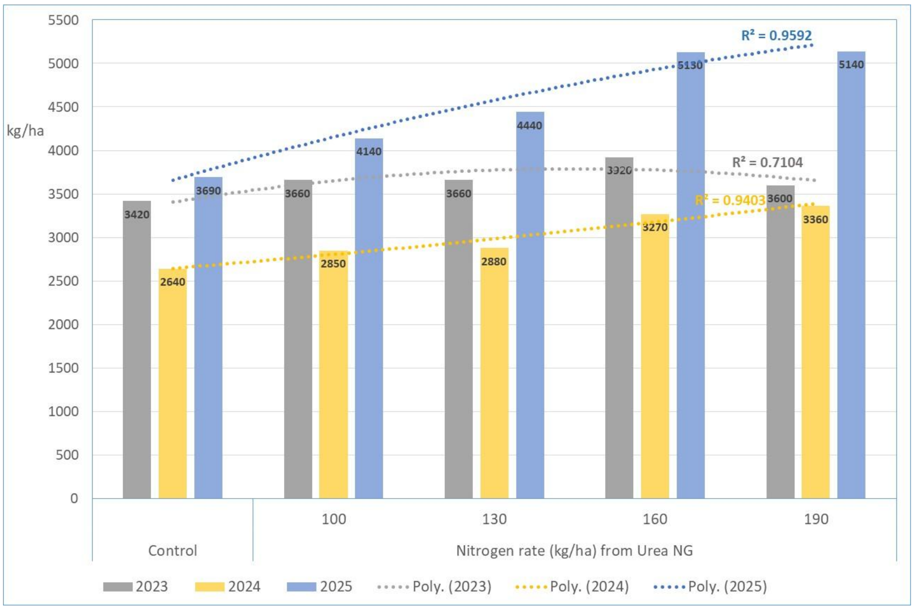

Figure 2. Oilseed rape yield at different nitrogen rates under the form of Urea NG (2023-2025 years)

As average values of the grain yield obtained according to the nitrogen rate for the three experimental years (2023, 2024, and 2025), the highest grain yield was registered at the nitrogen rate of 160 kg/ha in the case of using Urea NG (4107 kg/ha) (Figure 3). In the case of using Urea as nitrogen fertilizer, the highest grain yield was registered at the nitrogen rate of 190 kg/ha (3730 kg/ha), but with small differences compared to the grain yield obtained at the nitrogen rate of 160 kg/ha (80 kg/ha difference) and obtained at the nitrogen rate of 130 kg/ha (70 kg/ha difference). Increasing the nitrogen rate up to 190 kg/ha in the case of using Urea as nitrogen fertilizer does not lead to a significant yield increase. In a study performed in Poland between 2003–2013, Rutkowska (2019) found that increasing the nitrogen rate in the long term to 250 kg N ha^{-1} proved to be unjustified because it did not cause a significant increase in the yield. For both nitrogen fertilizers (Urea and Urea NG), the highest grain yields were registered in the favourable year 2025, then come those obtained in the year 2023 and then those obtained in the year 2024, which was the least favourable from a climatic point of view (Figure 3). In all years and for all the nitrogen rates, Urea NG proved to be superior to Urea fertilizer.

CONCLUSIONS

In the performed research, regarding the grain yield in the case of Urea fertilizer, there were highlighted the nitrogen rate of 130 kg/ha (60 kg/ha applied in autumn and 70 kg/ha applied early in the spring) under less favourable climatic conditions, and the nitrogen rate of 160 kg/ha (60 kg/ha applied in autumn and 100 kg/ha applied early in the spring) under good favourable climatic conditions. In the case of Urea NG fertilizer, it was highlighted the nitrogen rate of 160 kg/ha regardless the climatic conditions of the year.

The nitrogen rate of 190 kg/ha, despite the fact that gives the highest yields in some conditions, produces very small differences compared to the yields obtained at the nitrogen rate of 160 kg/ha for both Urea and Urea NG fertilizers, and therefore this variant of nitrogen rate is not justified.

In the performed research, Urea NG proved to be superior to Urea fertilizer, giving higher grain yields, but also having a higher dependence on the climatic conditions of the year.

Nitrogen is utilized by the oilseed rape plants according to the climatic conditions of the year: the better the climatic conditions of the year, the better the plants use the nitrogen, and higher grain yield are obtained at higher nitrogen rates.

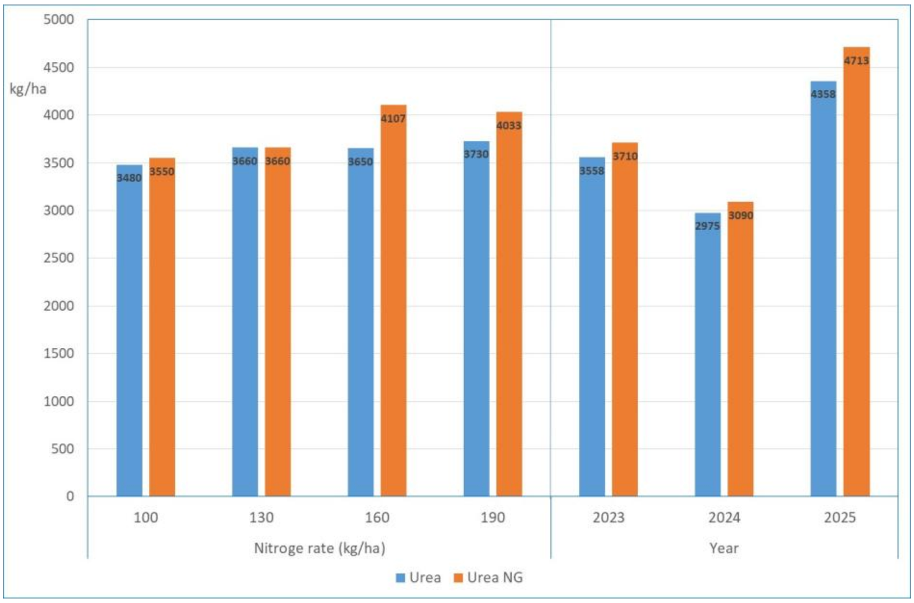

Figure 3. Oilseed rape yield as average values for the nitrogen rates and experimental years

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