Scientific Papers. Series A. Agronomy, Vol. LXVIII, No. 2, 2025
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

STUDIES ON THE INFLUENCE OF INPUT APPLICATION ON THE PRODUCTIVITY OF ROMANIAN WHEAT VARIETIES, AT ARDS CARACAL

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Abstract

Nutrients play a vital role in wheat production, both macro- and micronutrients being necessary for plants. Each nutrient has its own character and is involved in various metabolic processes of the life of wheat plants, that is why the influence of each cannot be clearly delineated. The purpose of the research is to present the yield results obtained at ARDS Caracal in the 2023-2024 agricultural year, for three Romanian wheat varieties (Glosa, Otilia and Carom), cultivated after different preceding crops (rape, peas, sunflower), using four different fertilization schemes. The obtained yields highlight the fact that each of the links in the technological scheme influences, to some extent, the quantity and quality of wheat production. Amidst prolonged soil droughts both in the fall of 2023 and in the spring-summer of 2024, the application of gradual-release inputs, doubled by biostimulants, managed to provide production increases of up to 22%, compared to the control variants. The results confirm that inputs play an essential role in increasing soil fertility, in full correlation with the fertilizers type, but also with the timing of their application.

Key words: *wheat crop, inputs, macronutrients, micronutrients, yields.*

INTRODUCTION

Nutrient deficiency and toxicity conditions inhibit normal plant growth and exhibit characteristic symptoms (Gomaa et al., 2015). For optimal growth, development and production, plants need all the necessary nutrients in balance. A balanced application of primary nutrients (N, P, K), secondary nutrients (S, Mg) and other micronutrients (Zn, B) is necessary to improve wheat yield (Pandey et al., 2020). Soil and crop nutrient requirement tests should be conducted periodically, in order to identify the recommended amount of fertilizer for the wheat crop in that year (Saquee et al., 2023).

A study conducted on clay soils in Bangladesh shows that wheat yield was significantly affected by combinations of inputs with secondary macronutrients, S and Mg, but also micronutrients Zn and B, together with the recommended dose of NPK – 100 kg N + 30 kg P + 70 kg K/ha, expressed in active substance (Azad et al., 2021). Plant height and the number of tillers per plant had significantly higher values than the control in each of the fertilization variants proposed for testing. Similar research has been carried out in Romania, in several areas of the country, by researchers such as Bacanu et al. (2019), Berca et al. (2019), Cernat et al. (2020), Cioineag & Cristea (2015), Horoias et al. (2013), Mihalache et al. (2014) and many others.

An efficient plant nutrition system can also be defined as that interaction between the different agrochemical, biochemical, technological and managerial measures that lead, with minimum costs and maximum yields and quality, to satisfying the farmers' requirements, but also of the environment and society (Berca, 2011).

Although new nutritional products are constantly emerging, the most difficult task is to test their practical effectiveness, through research over several years, so that the long-term influence they have on the soil (Bajgiran, 2013) and the crops they target becomes clear.

An example of such a product is the biofertilizer Rom-Agrobiofertil NP, a fertilizer based on three bacterial strains (*Azospirillium lipoferum*, *Azotobacter chroococcum* and *Bacillus megaterium*), which, following testing in an organic wheat crop, led to average production

increases of 350 kg/ha (Toader et al., 2019). Good results were also obtained in other field crops (rapeseed, sunflower). Following the evaluation of the pedo-climatic parameters of the ecosystem, the biometric data of the crops and the production differences, major positive differences were identified in favor of the bacterial biopreparations, in the soil-plant-production system (Toader et al., 2020).
Another study (Ali et al., 2022) presents the results of *T. harzianum* application in combination with foliar applied zinc and iron, which significantly positively influences wheat plant height, yield, number of grains/ear and harvest index. The current study can be successfully used for bread wheat development programs (Rosculete et al., 2023).

The effect of plant growth biostimulants results from the synergy of several components, in different concentrations, by increasing the absorption of minerals from the soil by plants and by improving the efficiency of the use of these nutrients. Considering the multi-elemental composition of the amino acid hydrolysates tested by Popko et al. (2018) - small amounts of macroelements: 2.8-3.5% N, 0.8-1.1% P_2O_5, 3.9-4.5% K_2O and microelements –, it is suggested that their function is to increase the absorption of nutrients by plants from the environment.

At the same time, meat and bone meal contains appreciable amounts of total nitrogen (8%), phosphorus (5%) and calcium (10%). Therefore, it can be a useful fertilizer for various crops, including wheat (Jeng et al., 2006). Similar effects are obtained with composts from sewage sludge, also sources of macro and micronutrients that can successfully contribute to crop fertilization (Safta & Ilie, 2022).
As a conclusion of the results obtained, in the mentioned research, different types of inputs have been shown to be beneficial in improving nitrogen use efficiency and crop yield under low nitrogen applications (Li et al., 2023), which provides them with an economic advantage.
Starting from the examples identified in the specialized literature, the purpose of this research was established, namely to exemplify how the application of different inputs influences the productivity of different wheat varieties, depending on the preceding crop.

MATERIALS AND METHODS

The experiments were carried out on the farms of ARDS Caracal, located in the southern part of Romania, in Olt County, on chernozem-type soils. Romanian wheat varieties were tested.
The main objective of the paper is represented by the study of the influence of some technological factors (variety, the previous crop and the type of fertilization with chemical fertilizers and biostimulators) on the elements of productivity and production, in the wheat crop.
Regarding the evolution of the wheat crop, for each of the test variants the following parameters were periodically monitored (Picture 1, a and b):

- number of plants/sqm;
- number of tillers/plants;
- plants height (cm);
- number of ears/sqm;
- ears length (cm);
- number of spikelet's/ears;
- number of grain/ears;
- grain weight/ear (g).

Photo 1. Evaluation of the development stage of wheat plants (original photos from 21.03.2024): a - counting plants/sqm; b - number of tillers/plants

The climatic conditions of the 2023-2024 agricultural year weren't mentioned, since all the research plots benefited from the same environmental conditions. However, being an area with prolonged droughts that repeat annually, as were those recorded in the fall of 2023 and in the spring-summer of 2024, the application of correct fertilization schemes is even more important for the good development of the wheat crop. A second aspect is the availability of plant inputs, amid the acute lack of water in the soil.

As control, the variant without inputs in autumn, at the establishment of the crop, followed by a single application of inputs in spring, at the resumption of vegetation – 250 kg/ha ammonium nitrogen, was chosen. The factors included in the technological scheme of the research are detailed in Table 1.

Table 1. Factors used to draw up the technological scheme of the research

Wheat variety (A)	Previous crop (B)	Fertilization scheme (C)
A1 – Glosa A2 – Otilia A3 – Carom	B1 – peas B2 – rapeseed B3 – sunflower	**C1** – *unfertilized in autumn + ammonium nitrate 250 kg/ha in spring (control)*
		C2 – *fertilized in autumn with NPK 250 kg/ha + ammonium nitrate 250 kg/ha in spring in a single application*
		C3 – *fertilized in autumn with NPK 250 kg/ha + ammonium nitrate 250 kg/ha in spring, applied in two fractions*
		C4 – *fertilized with NUTRI TOP80 250 kg/ha in autumn + UREA NG with gradual release 250 kg/ha*

Source: own data

For data accuracy, three 5 sqm microplots (three repetitions) were delimited from each test plot, by excluding the influence of the edges. The harvesting was carried out with small-sized equipment, dedicated to research activities. The harvested quantity of grains was weighed, its humidity was determined, in order to calculate the production per hectare at standard humidity (14%). In the present case, the emphasis was placed on the quantitative yield of the analysed plots, even if the qualitative evaluation of the production was also carried out.

The data related to yields were managed in Excel, in complex tables, and were later processed using the Anova program, in order to perform statistical analysis in interaction.

RESULTS AND DISCUSSIONS

Starting from the productions of each research plot, average productions per hectare were calculated, by relating them to 14% humidity, for uniformity. The results were entered into the Anova statistical program and processed for a 5% reference interval, with the aim of identifying factors that exceed it, either at the lower or upper limit.

We started from the first factor (A – variety), for which the average data from Table 2 were obtained. The general average of the entire experiment was chosen as control, against which the productions of the three Romanian varieties – Glosa, Otilia and Carom – were compared.

Table 2. One-way analysis for factor A – analysis of variance for the tested wheat varieties

Variety	Average yield (q/ha)	Ratio to the control (%)	Difference to the control (q/ha)	Statistical influence
A1 – Glosa	48.80	98.34	-0.82	
A2 – Otilia	53.31	107.43	3.69	*
A3 – Carom	46.75	94.22	-2.86	
General average	49.62	100.00	–	Control
Limit difference (LD) 0.1%				5.2111
Limit difference (LD) 1%				4.0172
Limit difference (LD) 5%				3.0250
Limit difference (LD) 10%				2.5289
Fisher factor (F)				9.7752
Corrected dispersion (S2)				404.9494
Error of corrected dispersion				41.4263
Correlation ratio (r^2)				0.4672
Correlation coefficient (r)				0.6835

Source: own data

The statistical results obtained from the variance analysis program highlight the fact that there is a significant difference between the productions obtained by the three wheat varieties in the 2023-2024 agricultural year. Carom is the variety with the weakest performance, namely 46.75 q/ha, followed by Glosa, with 48.80 q/ha. The difference between the two isn't significant. However, the Otilia variety is noteworthy, with 53.31 q/ha, which places it at the top of the hierarchy, with very significant positive differences, compared to the other two.

The correlation coefficient (r) is medium, which confirms the accuracy of the data. The entire analysis shows that the choice of variety is essential for achieving the highest possible yields, in a similar technological scheme.

The graph in Figure 1 exemplifies the 5% confidence interval (LD5%), outside of which only the Otilia variety is found, as well as the function that was the basis of the obtained curve.

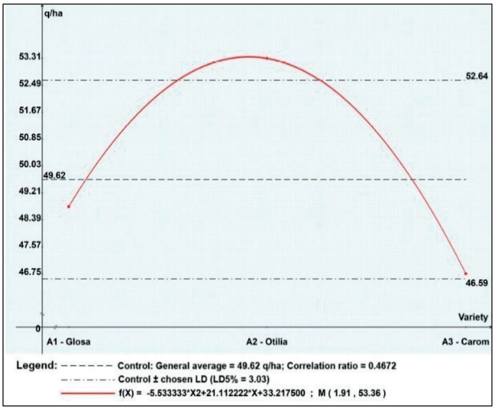

Figure 1. Graphical representation of the unifactorial analysis for the varieties included in the research (original)

A similar approach was used for the other two factors. Regarding the second one (B – preceding crop), the average data from Table 3 were obtained. The general average of the entire experiment was also chosen as the control, although the variants were subsequently compared with each other – wheat after peas, rapeseed and sunflower.

Table 3. One-way analysis of factor B – analysis of variance for the tested preceding crops

Preceding crop	Average yield (q/ha)	Ratio to the control (%)	Difference to the control (q/ha)	Statistical influence
B1 – peas	52.14	105.08	2.52	
B2 – rapeseed	50.10	100.97	0.48	
B3 – sunflower	46.62	93.95	-2.99	o
General average	49.62	100.00	–	Control
Limit difference (LD) 0.1%				4.9523
Limit difference (LD) 1%				3.8176
Limit difference (LD) 5%				2.8748
Limit difference (LD) 10%				2.4033
Fisher factor (F)				7.4952
Corrected dispersion (S2)				280.4196
Error of corrected dispersion				37.4133
Correlation ratio (r^2)				0.4200
Correlation coefficient (r)				0.6481

Source: own data

Wheat yields aren't significantly different when the crop comes after peas or rapeseed, both known to be good precursors for wheat, with high capacity to enrich the soil with nitrogen through biological processes. It is confirmed that both peas and rapeseed are good precursors for wheat, with significantly positive differences compared to the plots grown after sunflower: +5.52 q/ha after peas, +3.48 q/ha after rapeseed. Compared to the general average (control), it's observed that it's much higher than the productions offered by the two favorable preceding crops (peas and rapeseed), and sunflower stands out as being significantly negative. This aspect is also observed in the graph in Figure 2, where the function used to calculate the variance analysis leads to an almost linear evolution, starting from sunflower at the bottom, continuing with rapeseed and then with peas, at the opposite pole.

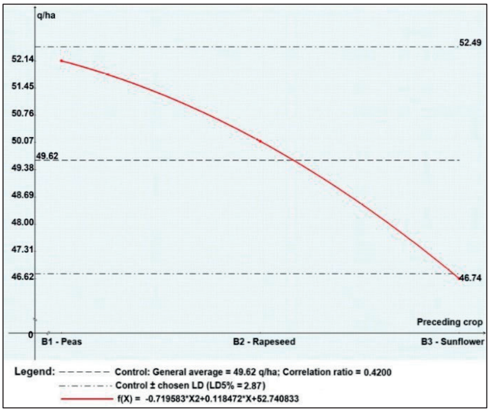

Figure 2. Graphical representation of the unifactorial analysis for the preceding crops included in the research (original)

Main part of the research is the one that targets fertilization systems, in this case the control being C1 (Table 4), namely the application of a single dose of fertilizers in spring.

From the detailed analysis of yields, it can be concluded that in the case of interactions between factors, the control variant, without fertilization in the autumn, when establishing the wheat crop, is sometimes beneficial and offers multiple advantages – when wheat is grown after peas, the lack of fertilizer application in the autumn leads to increased productivity, while reducing input costs. In this case, autumn fertilization can induce the loss of the amount of nitrogen that is already in the soil.

Table 4. One-way analysis of factor C - analysis of variance for the tested fertilization systems

Fertilization system	Average yield (q/ha)	Ratio to the control (%)	Difference to the control (q/ha)	Statistical influence
C1	46.11	100.00	–	Control
C2	46.54	100.94	0.43	
C3	49.68	107.74	3.57	*
C4	56.15	121.79	10.05	***
Limit difference (LD) 0.1%				4.8318
Limit difference (LD) 1%				3.7314
Limit difference (LD) 5%				2.8134
Limit difference (LD) 10%				2.3551
Fisher factor (F)				21.5002
Corrected dispersion (S2)				580.7156
Error of corrected dispersion				27.0098
Correlation ratio (r^2)				0.6728
Correlation coefficient (r)				0.8202

Source: own data

When averaging the varieties and preceding wheat crops, it turns out that the difference between C1 and C2 is one without statistical significance. Slightly significant increases in production are generated by the C3 system, with fertilization both in autumn and in spring, in the form of two graduations. The C4 system is the only one that, at the level of a rotation like the one studied, leads to very significant increases, of 10.05 q/ha, which represents an increase of almost 22%.

By plotting the data in Table 4, Figure 3 was obtained, which highlights that the C3 and C4 fertilization systems exceed the confidence interval provided by the 5% limit differences. The function underlying the graph is supported by a correlation ratio (r^2) of 0.6728, and therefore by a correlation coefficient of high value (r = 0.8202).

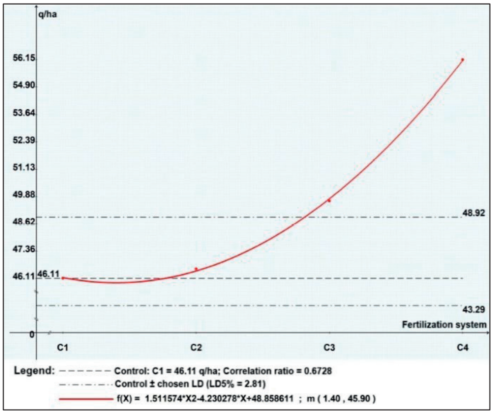

Figure 3. Graphical representation of the unifactorial analysis for the fertilization systems included in the research (original)

The continuation of the statistical analysis is carried out through the interactions of each two factors, and finally of the three factors, in random order, depending on what is desired to be highlighted. For this point in the research, the three-factor analysis is much too detailed, generating a graph for each intersection of the factors.

Unifactorial data processing led to the conclusion that the fertilization system (factor C) and the preceding crop (factor B) are the ones that most significantly influence wheat yields. As a result, the bifactorial C x B analysis was chosen as representative, in which the control was fertilization C1 and the preceding crop B3 (Table 5).

Table 5. Two-way analysis for factors C and B - analysis of variance for wheat yields in 2023-2024

Fertilization	Preceding crop	Average yield (q/ha)	Ratio to the control (%)	Difference to the control (q/ha)	Statistical influence
C1	B1	51.02	127.37	10.96	***
	B2	47.25	117.98	7.20	**
	B3	40.05	100.00	–	Control
C2	B1	48.11	120.11	8.05	**
	B2	45.97	114.78	5.92	*
	B3	45.54	113.69	5.48	*
C3	B1	51.36	128.22	11.30	***
	B2	49.75	124.20	9.69	***
	B3	47.93	119.66	7.87	**
C4	B1	58.08	145.00	18.03	***
	B2	57.42	143.37	17.37	***
	B3	52.96	132.23	12.91	***
Limit difference (LD) 0.1%					9.3048
Limit difference (LD) 1%					7.1961
Limit difference (LD) 5%					5.4319
Limit difference (LD) 10%					4.5458
Fisher factor (F)					6.8251
Corrected dispersion (S2)					229.7583
Error of corrected dispersion					33.6637
Correlation ratio (r^2)					0.6785
Correlation coefficient (r)					0.8237

Source: own data

By comparison with the chosen control – applying fertilization only in spring, in a single dose (C1), after sunflower (B3) –, it is observed that all other variants offer statistically significant increases in yield. Very significant are the production increases offered by the C4 fertilization system (Nutri Top80 in autumn + urea NG with gradual release, in spring), regardless of the preceding crop. Although at a great distance, in second place is the C3 system, with a single application of inputs in autumn and fractionated in spring (2 applications), whose effect seems to be to standardize productions, but at an average level.

In addition, for wheat grown after peas and rapeseed, the C4 system is the only effective one, with the other three yields remaining constant. Especially for the preceding peas, but also for rapeseed, autumn fertilization leads to moderate yield decreases or brings no benefit (Figure 4).

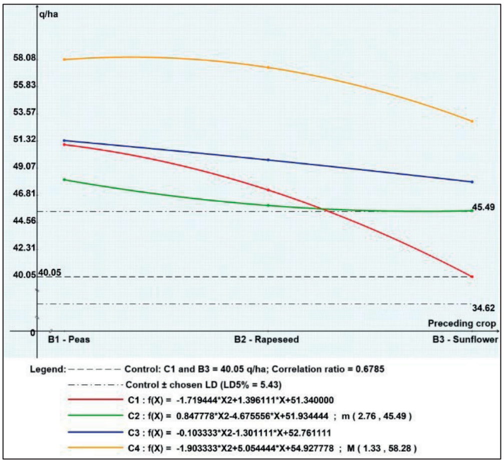

Figure 4. Graphical representation of the bifactorial analysis for factors C and B of the research (original)

On the other hand, for the case where the previous crop is sunflower, the application of autumn fertilization is crucial, providing a production increase of at least 500 kg/ha.

CONCLUSIONS

Over time, research conducted on various crops has proven that excessive use of fertilizers ends up causing losses of nutrients from the soil, which become inaccessible to plants and pollute the environment, without bringing economic benefits. According to the presented data, it can be concluded that fertilization should be established according to the preceding crop, which would increase the production level of the wheat crop and reduce expenses at the farm level.

If the classic C3 fertilization system brings production, regardless of variety and preceding crop, to an average level, the C4 system, with new, gradual-release inputs, applied both in autumn and spring, offers increases in yield levels of up to 22%, equivalent to 10 q/ha, very significantly positive compared to the C1 control.

Our own results confirm that inputs play an essential role in increasing soil fertility, in full correlation with the type of fertilizers and the timing of their application, as well as the fact that each of the technological links plays an essential role in the level of production obtained.

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