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WHEAT BIOLOGICAL YIELD VARIATION IN RELATION TO NITROGEN AND FOLIAR BIOSTIMULATOR TREATMENT

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Abstract

The study evaluated the variation of biological yield in wheat, the Alex variety, under the influence of nitrogen and foliar biostimulator. Nitrogen was applied to the ground, in five variants (N0, N50, N100, N150, N200), in doses between 0 to 200 kg ha^{-1}. The Superfifty biostimulator (Sf) was applied foliar, six variants (Sf0, Sf1, Sf2, Sf3, Sf4, Sf5) on each level of N fertilization, in concentrations between 0 - 5 L ha^{-1}. Biological yield was determined in the BBCH code 9 stage. The variation of the biological yield of wheat, Alex cultivar, under the influence of fertilization with Superfifty product, in the six concentrations tested, on the five levels of N, was described by polynomial equations of order 2 and 3, in statistical safety conditions. The regression analysis evidenced the variation of biological yield, as the direct influence and interaction of the two factors (N and Sf), in general conditions of statistical safety, according to $R^2 = 0.984$, $p < 0.001$. The ANOVA test confirmed the statistical certainty of the values of the coefficients of the obtained equation ($p = 0.00749$ for a; $p << 0.001$ for b; $p << 0.001$ for c; $p < 0.001$ for d; $p << 0.001$ for e).

Key words*: biological yield, foliar biostimulator, nitrogen, optimal doses, wheat.*

INTRODUCTION

Productivity of agricultural systems and crops (reproductive efficiency) is approached from different perspectives (Edgerton, 2009; Shiferaw et al., 2011; Willcox et al., 2018).

Harvest indices are of interest for the analysis and characterization of crops or agricultural systems, in relation to different ecological, economic and social factors of influence (Uncovich et al., 2010; Li et al., 2020; Vannevel and Goethals, 2020).

Knowledge of biological production and harvest indices is of interest from an ecological, agronomic perspective, but also of genetic strategies and breeding programs (Donald & Hamblin, 1976; Valizadeh et al., 2014; Nadolska-Orczyk et al., 2017; Kobata et al., 2018; Bailey-Serres et al., 2019; Sabella et al., 2020).

The biological yield of agricultural crops varies depending on the species, the cultivated genotype, the pedoclimatic conditions, the cultivation technologies, stress factors, etc. (Jing et al., 2016; Khan, 2016; Trivedi et al., 2017; Najafi et al., 2018; Liu et al., 2020).

The variation of crop production was studied in relation to different organic and mineral fertilized resources and fertilizer doses (Blanchet et al., 2016; Ghosh & Devi, 2019; Mohamed et al., 2019; Adebayo & Sebetha, 2020; Cen et al., 2020).

Macroelements (NPK), under conditions of different fertilization resources, were studied in relation to physiological indices and quantitative and qualitative aspects of agricultural production, and under different soil and climatic conditions (Zhang et al., 2020).

Foliar fertilization with different fertilizers or biostimulators is of interest for supplementing plant nutrition, stimulating metabolic activity, with quantified effects in the quantitative and qualitative level of agricultural production in different crops (Niewiadomska et al., 2020).

In wheat crop, the variation of some physiological indices, of the elements of productivity, of the production and quality in relation to different soil and foliar treatments with macro- and microelements was studied (Rawashdeh & Sala, 2013, 2014a,b; Stepien & Wojtkowiak, 2016; Sobolewska et al., 2020).

Very useful are non-destructive methods and

applications for mobile devices, for the study of foliar indices in relation to the state of vegetation of plants (Drienovsky et al., 2017; Müller-Linow et al., 2019).
In order to evaluate the nutritional status of wheat, an index of expression of nutritional stress was proposed, in relation to the doses of nitrogen fertilization (Datcu et al., 2020).
At the same time, different models of fertilization optimization have been found for wheat crop, in relation to productivity, production quality and economic indices (Sala et al., 2011; Jahan & Amiri, 2018; Tabak et al., 2020; Woo et al., 2020).
The present study evaluated the influence of nitrogen fertilization and Superfifty foliar biostimulator on wheat biological yield, Alex cultivar, and were found mathematical models for dose optimization.

MATERIALS AND METHODS

The study evaluated the variation of biological yield in wheat, Alex cultivar, under the influence of nitrogen mineral fertilization, and Superfifty biostimulator foliar application.
The study was carried out in the conditions of a cambic chernozem soil, located within SDE Timisoara, BUASVM Timisoara, in the period 2018-2019.
Nitrogen was provided as ammonium nitrate in doses ranging from 0 to 200 kg a.s. ha^{-1}, with a variation unit of 50 kg, and the variants N0, N50, N100, N150, N200 resulted.
The Superfifty foliar biostimulator was applied on each level of N fertilization in concentrations of 0, 1, 2, 3, 4 and 5 L ha^{-1} (Figure 1).
The combination of the two fertilizing resources resulted in 30 variants, in three repetitions.
The biological yield was determined, by weighing at physiological maturity (evaluation was done at 1 m^2, three repetitions), in stage BBCH 9, Senescence (Meier, 2001).
The experimental data were analyzed by the ANOVA test. This analysis highlighted the presence of variance in the set of data experimentally obtained, and also confirmed the safety of the recorded data.
The regression analysis highlighted the biological response of wheat crop depending on the fertilization applied to the soil and foliar. The optimal values for nitrogen and the Superfifty foliar biostimulator were determined. PAST software (Hammer et al., 2001) and Wolfram Alpha (Wolfram, 2020) were used for statistical analysis of the data.

Figure 1. Aspect in the experimental field

RESULTS AND DISCUSSIONS

The study was conducted in conditions of a cambic chernozem soil, with a medium level of fertility. The differentiated nutritional conditions provided to the wheat crop, the Alex cultivar, through the two fertilizing resources used, led to a specific variation of plant growth and development. In response to the applied treatments, there was a variation of biological yield, determined at physiological maturity (BBCH 99, Senescence, harvested product), according to the values presented in Table 1.

Table 1. Variation of wheat biological yield under the influence of Superfifty foliar biostimulator on different levels of nitrogen, Alex cultivar

Variants	Superfifty biostimulator					
	Sf0	Sf1	Sf2	Sf3	Sf4	Sf5
N doses	Biological yield (g/m^2)					
N0	278	309	356	796	839	512
N50	428	716	844	866	1004	806
N100	613	739	857	920	1008	840
N150	784	830	874	967	1112	890
N200	906	1007	1042	1152	951	925

From the overall analysis of the results, the variation of the biological yield was registered between 278 g/m^2 at the control variant (N0, Sf0) and 1152 g/m^2 at the variant N200, Sf3.

The increase generated by each of the two fertilizer products used was analyzed, as well as the interaction effect; the increase generated by N in relation to foliar biostimulator (Sperfifty); the increase generated by foliar biostimulator (Superfifty) in relation to N; the interaction effect. The growth increase generated by N was between 150 to 628 g/m^2 in the case of Sf0; between 407 to 688 g/m^2 in the case of Sf1; between 488 to 686 g/m^2 in the case of Sf2; between 70 to 356 g/m^2 in in the case of Sf3; between 165 to 273 g/m^2 in the case of Sf4; and respectively between 294 to 413 g/m^2 in the case of Sf5. The growth increase generated by the foliar biostimulator (Superfifty) was between 31 to 561 g/m^2 on the N0 level; between 288 to 576 g/m^2 on the N50 level; between 126 to 395 g/m^2 on the N100 level; between 46 to 328 g/m^2 on the N150 level; and respectively between 19 to 246 g/m^2 on the N200 level.

The ANOVA Two-Factor test, Alpha = 0.001, confirmed the data safety and the presence of the variance in the set of experimental data obtained (Table 2).

It was analyzed the possibility to describe the variation of biological yield, depending on the Superfifty foliar biostimulator, through mathematical models as well as their statistical safety. The variation of the biological yield of wheat plants, Alex cultivar, under the influence of fertilization with Superfifty biostimulator, in the six tested concentrations (0-5 L ha^{-1}), on the five levels of N (N0-N200 kg ha^{-1}), was described by polynomial equations of order 2 and 3, in statistical safety conditions (Table 3).

Table 2. ANOVA Two-Factor test

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	797245.5	4	199311.4	18.6656	1.58E-06	7.096034
Columns	492932.7	5	98586.54	9.232673	0.000112	6.460562
Error	213560.1	20	10678.01			
Total	1503738	29				

Table 3. Equations for describing the variation of wheat biological yield, Alex cultivar, in relation to nitrogen fertilizer and Superfifty foliar biostimulator

Nitrogen doses	Equation	Eq No	P	R^2
N0	$BY_{(N0)} = -39.815x^3 + 266.36x^2 - 292.78x + 298.37$	(1)	p<0.001	$R^2 = 0.935$
N50	$BY_{(N50)} = -42.679x^2 + 292.71x + 436.79$	(2)	p<0.001	$R^2 = 0.936$
N100	$BY_{(N100)} = -8.6296x^3 + 35.115x^2 + 86.61x + 617.53$	(3)	p<0.001	$R^2 = 0.968$
N150	$BY_{(N150)} = -17.4444x^3 + 115.33x^2 - 119.03x + 801.19$	(4)	p<0.001	$R^2 = 0.867$
N200	$BY_{(N200)} = -28.196x^2 + 142.04x + 900.54$	(5)	p<0.001	$R^2 = 0.712$

(BY - biological yield at different N levels; *x* - value of Superfifty concentration)

The graphical distribution of the values, and of the obtained polynomial models are presented in Figure 2.

The variation of biological yield under the influence of the Superfifty biostimulator, on the level N0, N100 and N150 was described by polynomial equations of degree 3, in conditions of $R^2 = 0.935$ on the level N0, $R^2 = 0.968$ on the level N100, and $R^2 = 0.867$ on the level N150, respectively.

In the case of N50 and N200 nitrogen variants, polynomial models of degree 2 were obtained which described the variation of biological yield under the influence of the Superfifty biostimulator, under conditions of $R^2 = 0.936$ on the N50 level, and $R^2 = 0.712$ on the N200 level, respectively.

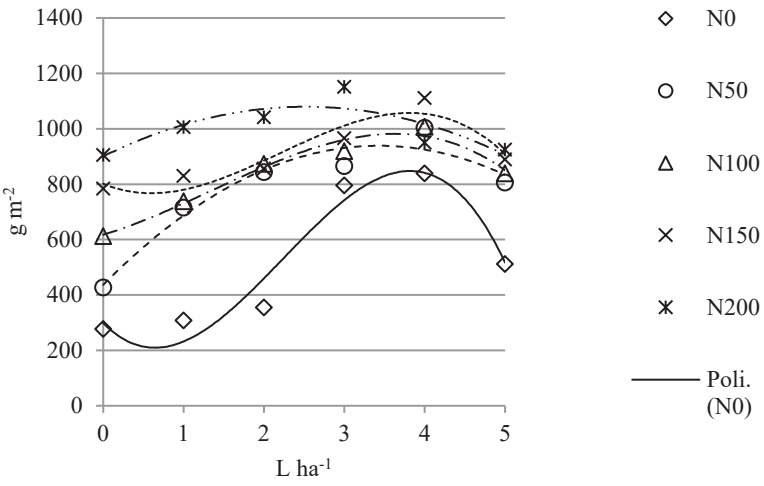

Figure 2. Graphic distribution of total wheat biological yield, under the influence of Superfifty biostimulator, on different nitrogen levels

The regression analysis led to the obtaining of a model of variation of the biological yield, under the concomitant influence, as direct action and interaction, of the two factors (N and Sf). Biological yield was described by equation (6), in general conditions of statistical safety, according to $R^2 = 0.984$, $p < 0.001$.

$$BY = ax^2 + by^2 + cx + dy + exy + f \quad (6)$$

where: BY - biological yield
x - N doses;
y - Foliar biostimulator concentration;
a, b, c, d, e, f - coefficients of the equation (6);
a = -0.0137295668549906;
b = -38.0143664245359;
c = 7.00308474576271;
d = 327.969362389023;
e = -0.702974011299434;
f = 0.

According to the ANOVA test and the values of the coefficients of equation (6) presented statistical certainty ($p = 0.00749$ for a; $p << 0.001$ for b; $p << 0.001$ for c; $p < 0.001$ for d; $p << 0.001$ for e).

The graphical distribution of the values of biological yield in wheat, Alex cultivar, depending on nitrogen (x - axes) and Superfifty (y - axes) is presented in 3D format (Figure 3), and in isoquant form (Figure 4).

Optimal values for x (Nitrogen doses) and y (Superfifty foliar biostimulator concentration) were calculated, starting from equation (6). Thus, the values $x_{opt} = 188.44$ kg N a.s. ha^{-1}, and $y_{opt} = 2.562$ L ha^{-1} (Superfifty foliar fertilizer) were obtained.

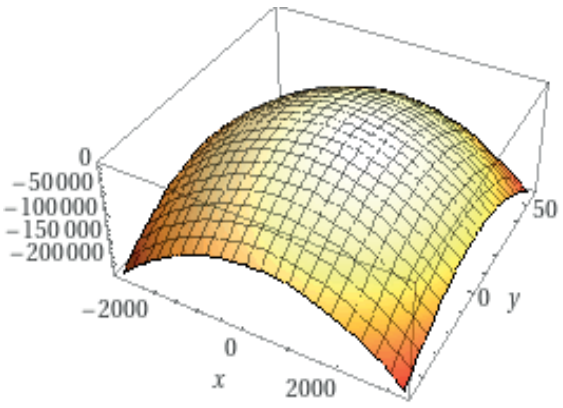

Figure 3. 3D variation model of biological yield in wheat, Alex cultivar, under the influence of Nitrogen (x - axes) and Superfifty foliar biostimulator (y - axes)

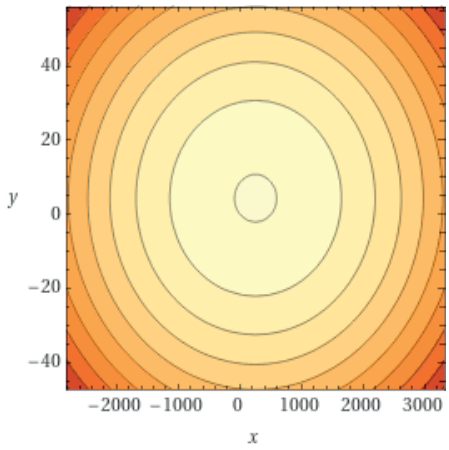

Figure 4. Isoquant variation model of biological yield in wheat, Alex cultivar, under the influence of Nitrogen (x - axes) and Superfifty foliar biostimulator (y - axes)

Yield and biological yield in wheat have been studied in relation to soil conditions (Woźniak & Gos, 2014; Sobolewska et al., 2020), to climatic conditions (Yang et al., 2019; Sabella et al., 2020; Shew et al. al., 2020), with the potential of cultivated genotypes (White & Wilson, 2006; Fayed et al., 2015; Ruiz et al., 2019), with the conditions of agricultural technologies (Robertson et al., 2016; Al-Zahrani et al., 2019), with the fertilization system (Mandic et al., 2015; Imran et al., 2017), with growth biostimulators (Popko et al., 2018; Szczepanek et al., 2018; Laurent et al., 2020 ; Wang et al., 2020).

Belete et al. (2018) found the variation of biological production and N content from straw to wheat, in relation to the N fertilization rate. Similar results were also reported by Worku et al. (2007) and Alemu et al. (2012). Hussain et al. (2006) found variations but also some similarities of biological production and productivity elements of wheat, four varieties for bakery, in relation to the N doses.

Al-juthery et al. (2019) reported the variation of physiological indices, biometric parameters and biological production of wheat under the influence of products with amino acids and nano-fertilizer. Favorable results on wheat biological yield, different genotypes, were also recorded in relation to foliar treatments with different fertilizers with macro- and microelements (Rawashdeh & Sala, 2014a; Khan et al., 2019; Rafiullah et al., 2020).

Under the present study, nitrogen fertilization and foliar fertilization with the Superfifty biostimulator led to increases in biological yield comparable to other similar studies, and in statistical safety conditions.

CONCLUSIONS

Nitrogen applied in variable rates between 0 - 200 kg ha^{-1} and the Superfifty biostimulator applied foliar in concentrations between 0 to 5 L ha^{-1}, generated variations of the biological production of wheat, Alex cultivar, in conditions of statistical safety of the results.

The variation of the biological yield, according to the foliar product Superfifty, on the five levels of N fertilization, was described by mathematical models of polynomial type, of degree 2 and 3, in conditions of statistical safety.

The direct and of interaction effect of the two products was evidenced by regression analysis and it was possible to calculate the optimal doses for N and Superfifty.

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