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DISPERSION AND REGRESSION ANALYSIS ON GRAIN YIELD AND NITROGEN FERTILIZATION OF TRITICALE VARIETIES I

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Abstract

The aim of the study is to analyze the responsiveness of two Bulgarian varieties of triticale to the rate of nitrogen fertilization in the formation of grain yield. The study area was Field Crops Institute - Bulgaria. The test period concluded 2015/2017. Were tested two varieties - 'Colorit' and 'Respect'. Were included in the experimental production tree rates of nitrogen fertilizer (kg/ha) - N_{60}, N_{120} and N_{180}. The phosphorus fertilizer was 60 kg/ha. Dispersion and regression analysis was applied to establish statistically significant influences of the studied factor and differences between the tested variants. Mineral fertilization at rates of 60, 120 and 180 kg N/ha had a confirmed statistical effect. The regression equations confirmed that the nitrogen rate has a strong influence on the grain yield. For both tested varieties, the largest increase in grain yield compared to the theoretical yield can be expected when fertilizing with 60 kg N/ha.

Key words*: grain yield, nitrogen fertilization, statistical analysis, triticale.*

INTRODUCTION

Triticale is the first man-made culture. From the announcement of the first constant wheat-rye hybrids, triticale has come a long way to the formation of modern varieties. Today, culture is a key ingredient in the diet of farm animals. World grain production for 2018 amounts to 12,802,592 tons (FAOSTAT).

Interest in triticale is manifested in all research areas in the field of crop production. The main goal of scientists is to increase grain yield. In plant growing every human interventional invariably represents major and sometimes irrevocable change in the nature and properties of the original soil (Bijay-Singh, 2018). Fertilization is an important measure to increase soil nutrients and improve crop growth conditions (Hu et al., 2020). The impact of synthetic fertilizers on the environment can be negative and has been debated for decades by the scientific community. In this sense, it is necessary for specialists to forecast the yield depending on the application of fertilizers. One of the most reliable prediction methods is regression analysis. Linear regression analysis is probably the simplest and most popular way to measure the relationship between continuous predictor and response variables (Hope, 2020). Regression analysis answers question about the dependence of a response variable on one or more predictors, including prediction of future values of a response, discovering which predictors are important, and estimating the impact of changing a predictor or a treatment on the value of the response (Weisberg, 2005). This technology has been used for for nitrogen application strategies to obtain optimum yields and grain quality (Hansen, Jorgensen and Thomsen, 2002). The analysis of variance determines the influence of a given factor (factors) on a selected feature, and assesses the degree of this influence. An important task of the variance analysis is the estimation of the differences between the samples (gradations) in the dispersion complex, as the random variant serves as an error of the differences. In this respect, analysis of variance is a more efficient and economical method than others.

The aim of the study is to analyze the responsiveness of two Bulgarian varieties of triticale to the level of nitrogen fertilization in the formation of grain yield.

MATERIALS AND METHODS

The study area was Field Crops Institute-Chirpan, Bulgaria (42 ° 11'58 "N, 25 ° 19'27" E). The test period concluded 2015/2017. The experimental plot was 12 m^2 in four replications. Were tested two varieties triticale - 'Colorit' and 'Respect' with sunflower

predecessor. Were included in the experimental production tree rates of nitrogen fertilizer (kg/ha) - N_{60}, N_{120} and N_{180}, incorporated at tillering phase. The phosphorus fertilizer was 60 kg/ha, incorporated in autumn. As a control option was adopted N_0P_0.

To determine the statistically significant effects of the studied factors and differences (LSD) between the tested variants, analysis of variance (ANOVA) was applied. The following model was applied:

$$Yi=\mu+ ai+ei$$

where: *Yi* are the meaning and number of the dependent and factor variables; μ are the average of the test results; *ai* is the effect of factors; *ei* is random error.

Data regression was determined with the software Statistica 13.0 (TIBCO, Software, 2018). The following model of regression dependence equation was used:

$$y=a+bx,$$

where: *y* are the values of the dependent variable or function (in our case grain yield); *x* are the values of the independent variable or argument (in our case fertilization rates); *a* is the parameter (coefficient) reflecting the distance from the zero point of the coordinate system to the beginning of the regression line; *b* is the angular coefficient characterizing the slope of the regression line.

RESULTS AND DISCUSSION

The data presented in Table 1 shows that the significant effect of fertilization on grain yield (GY) increased with increasing fertilizer rate for both varieties. It is important to note that the N_{120} and N_{180} variants have the same statistically significant effect (P=0.1%) for both the 'Colorit' variety and the 'Respect' variety. Application of 60 kg N/ha showed higher statistical reliability (P=1.0%) for 'Respect' variety compared to 'Colorit' variety (P=5.0%).

Table 1. GY variance analysis on average for the study period (2015-2017)

Fertilization rates	'Colorit' relative to the variant without fertilization	'Respect' relative to the variant without fertilization
N_0	-	-
N_{60}	*	**
N_{120}	***	***
N_{180}	***	***

ns: no significant; *, **, *** significant at P=5%, P=1% and P=0.1%

The analysis of the total dispersion shows that the effect of fertilization for the variety 'Colorit' was proved with a degree of influence of 40.4% (Table 2), while the degree of influence of the Respect factor was 45.2% of the total variant. Gulmezoglu and Aytac (2010) reported that the effect of N fertilizer levels on grain yield were statistically significant (P<0.01). Janašauskaite (2013) reached the same results.

Table 2. Dispersion analysis of GY average for the study period (2015-2017)

Varieties	Source of variation	*SS*	*df*	*MS*	η_i
Colorit	A	243526	3	81175.34***	40.37436
	Error	359644	44	8173.727	59.62565
	Total	603170	47		
Respect	A	89293.5	3	29764.5***	45.01917
	Error	109052	44	2478.5	54.98083
	Total	198345.5	47		

ns: no significant; *, **, *** significant at P=5%, P=1% and P=0.1%

Table 3 presents the statistical significance of the variants compared to the previous (lower) nitrogen rate. In the case of 'Colorit' variety with a proven effect on the formation of GY was 60 kg N/ha at P=5%. With increasing fertilization rates, both norms remained outside the statistically significant effect. Similar results were observed for the 'Respect' variety. The application of N_{60} showed a higher degree of significance P=1% compared to the variety 'Colorit'. The results of our study are confirmed by the observation of Bielski et al. (2020). The authors reported that when applying a higher fertilization rate in the study, the GY was high, but the difference with the lower rate was not statistically significant.

Table 3. Statistical significance between fertilization variants in the formation of GY average for the test period (2015/2017)

Fertilization rates	'Colorit' relative to the lower fertilization rate	'Respect' relative to the lower fertilization rate
N_0	-	-
N_{60}	*	**
N_{120}	ns	ns
N_{180}	ns	ns

ns: no significant; *, **, *** significant at P=5%, P=1% and P=0.1%

In order to differentiate the influence of mineral fertilization in the formation of grain yield, a regression analysis was performed for each variety, on average for the test period. When

comparing 4 mathematical models for each variety, it was found that the grain yield changes under the influence of the increasing nitrogen rate in regression lines.

Figure 1 shows that for the variety 'Colorit' the values of the nitrogen norm showed a high, positive correlation with the values of the realized grain yield (r=0.979**). In this case, the dependence assumes proven positive values. The results showed that the nitrogen rate has a strong influence on the grain yield. Our results are confirmed by a number of studies, including those of Los Galetto et al. (2017) and Gulmezuglu and Aytac (2010). The statistical reliability of the coefficients in the equation and the mathematical model was confirmed. The four fertilization rates studied were within the confidence interval. The variant without fertilizer and 180 kg N/ha variants showed a lower-than-expected grain yield. Fertilization with N_{120} coincided with the predicted GY. However, the increase in the impact of N_{60} was 209.2 kg /ha more than the theoretical change.

For the 'Respect' variety, a strong and positive correlation was also observed between the values of the nitrogen rates and the realized grain yield (r=0.973**). The dependence also assumes proven positive values. The coefficients in the equation are statistically significant and the mathematical model was reliable. From Figure 2 it can be seen that the variant without fertilization and the maximum fertilizer rate realized a lower GY than the theoretical yield. Fertilization with 60 and 120 kg N/ha resulted in higher yield values than expected. However, for N_{60} the increase was higher (117.4 kg/ha) compared to N_{120} (78.1 kg/ha).

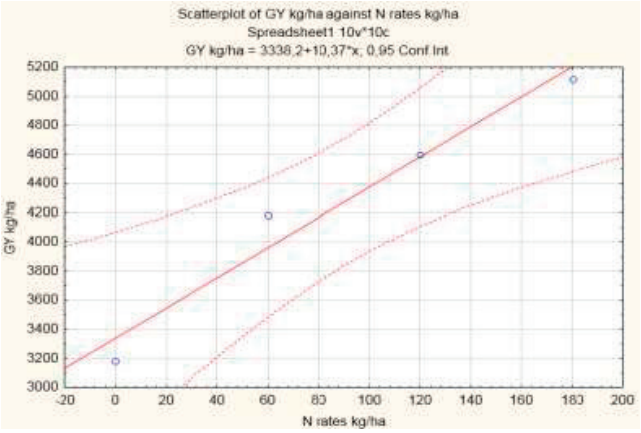

Figure 1. Theoretical change in grain yield under the influence of mineral fertilization on average for the test period (2015-2017) for the variety 'Colorit'

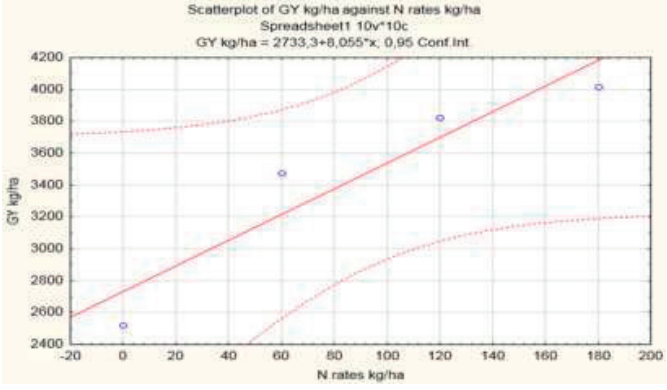

Figure 2. Theoretical change in grain yield under the influence of mineral fertilization on average for the test period (2015-2017) for the variety 'Respect'

CONCLUSIONS:

The variance analysis showed a significant effect of fertilization in both triticale varieties. Mineral fertilization at rates of 60, 120 and 180 kg N/ha had a confirmed statistical effect. However, the differences between N_{60}-N_{120} and N_{120}-N_{180} were unproven for both varieties. Only the difference between the control variant and N_{60} had a proven effect. The regression equations confirmed that the nitrogen rate has a strong influence on the grain yield. For both tested varieties, the largest addition to grain yield compared to the theoretical yield can be expected when fertilizing with 60 kg N/ha.

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