INFLUENCE OF NITROGEN FERTILIZATION IN COMBINATION WITH FOLIAR FERTILIZATION ON THE STRUCTURAL ELEMENTS OF THE SPIKE IN TRITICALE VARIETIES (X *TRITICOSECALE* WITTM.)

Stefka DOBREVA*, H. KIRCHEV, Angelina MUHOVA*****

Field Crops Institute-Chirpan, stefanovadobreva@gmail.com

2 G. Dimitrov bul., 6200 Chirpan, Bulgaria

****Agricultural University-Plovdiv , hristoforkirchev@abv.bg***

12 Mendeleev str., 4000 Plovdiv, Bulgaria

*****Field Crops Institute-Chirpan, muhova.angelina@gmail.com***

2 G. Dimitrov bul., 6200 Chirpan, Bulgaria

***Abstract**: In the experimental field of Institute of field crops, Chirpan, Bulgaria, during the period 2014-2017, a field experiment has been carried out with four triticale varieties: Colorit (standard), Attila, Boomerang and Respect. The experiment was based on the fractional plot method in four replications with a plot size of 12 m^2. The effect of nitrogen fertilization in combination with leaf fertilizer has been studied. The following structural elements of the spike has been studied - mass of the spike, g; grain mass in spike, g; spike length, cm; number of grains in spike and harvest index of the spike, calculated as the ratio between the mass of the grains in the spike and the mass of the whole spike. In order to establish statistically significant differences between the variants, a dispersion analysis (ANOVA) was applied, and three-factor dispersion analysis (MANOVA) was used to establish the independent action of the factors. The study found out that the combination of mineral and foliar fertilization raises the structural elements of the spike in all varieties. In the study of the structural elements of the spike, with the longest spike of 12,6 cm and the largest number of grains - 81,5 is the Respect variety, and with the largest mass of grains is Attila - 3,91 g.*

***Key words:** triticale, spike, fertilization.*

INTRODUCTION

One of the main advantages of triticale is its high productivity. This advantage is due largely to the structure of the spike of triticale inherited from both parental species - wheat and rye. From wheat it inherited the dense and glimmering spike, and from the rye - the long spike. It is the combination of the different structural elements of the spike, which is a major factor for high productive potential in the different triticale varieties (AKMANAYEV& PESHINA, 2014; ĐEKIĆ ET AL., 2012; GREBENNIKOVA ET AL., 2011; GUIDOBALDI & MAICH, 2002; KONDIC ET AL., 2013; KOCIUBA ET AL., 2010; KOZDÓJ ET AL., 1998; KNEZEVIC ET AL., 2016; MADIC ET AL., 2015; MILOVANOVIC ET AL., 2014; STOYANOV & BAYCHEV, 2018; SWEENEY ET AL., 1992; ZAJAC ET AL., 1999).

MATERIAL AND METHODS

In the experimental field of Institute of field crops, Chirpan, Bulgaria, during the period 2014-2017, a field experiment has been carried out with four triticale varieties: Colorit

(standard), Attila, Boomerang and Respect. The experiment was based on the fractional plot method in four replications with a plot size of 12 m^2.

The experiment was set after a predecessor sunflower. The soil tillage after harvesting the precursor was disking and cultivation, the number of them being adapted to the condition of the soil. Sowing was done at the appropriate agro-technological time and depending on the weather conditions of the year. For the sowing, a seed drill and a seed rate of 550 germinating seeds per m^2 were used.

The effect of nitrogen fertilization in combination with foliar fertilizer has been studied. Foliar fertilizers Lactofol O were tested. The Lactofol complex suspension fertilizers for leaf application contain macro and micro elements, bio stimulants - vitamins and physiologically active substances (MILEV AND TODOROVA, 2014). The foliar fertilizer Lactofol is introduced twice in the tillering and spike emergence stages at a dose of 600 ml/da early in the morning by manually sprinkling the plants.

The following structural elements of the spike has been studied - mass of the spike, g; grain mass in spike, g; spike length, cm; number of grains in spike and harvest index of the spike, calculated as the ratio between the mass of the grains in the spike and the mass of the whole spike. Average data for the three years of the study was used.

In order to establish statistically significant differences between the variants, one-way dispersion analysis of variance (ANOVA) was applied, and three-way multivariate analysis (MANOVA) was used to establish the independent action of the factors.

RESULTS AND DISCUSSION

The length of the spike, when tested triticale, was amended in a different degree under the influence of the factors variety, fertilization and foliar treatment with Lactofol (Table 1).
On average, for the three years of the study, the shortest spikes are without fertilizer application and not treated with foliar fertilizer. In such conditions the shortest spike was formed in Boomerang variety – 9,3 cm, followed by Respect – 9,6 cm, Colorit – 9,8 cm, and with the longest spike in the conditions without mineral and leaf fertilization has formed variety Attila - 10 cm. All these differences, however, are statistically unreliable against the standard variant, and can be considered as occasional.

In a study of the interaction of the factors with dispersion analysis, on average over the three years, the non-fertilizing and Lactofol independent effects remained statistically non-significant in all varieties as well as at the lowest N_6 level in Colorit and Respect. The trend in the medium (N_{12}) and high (N_{18}) fertilizer norms, whether with or without Lactofol, is the opposite. The lengths of the spikes in these variants have been shown to be higher than the control variant.

When considering the independent action of the factors on the length of the spike, the nitrogen fertilization was with great statistical significance (Table 2). All applied nitrogen fertilization levels were well-differentiated compared to the non-fertilized variant. The N_6 norm is demonstrated at a LSD of 1%, and with the highest rank (0,1% of LSD) being the N_{12} and N_{18} norms. The lowest fertilizer rate (N_6) increases the length of the spike by 10.0%. In N_{12} fertilization, the spike length was increased by 21,0% and the highest fertilization rate (N_{18}) increased the spike length by 26,0%.

Regarding the influence of the specificity of genotype, no reliable differences were recorded and this factor remained with no significance. Regarding single action of foliar fertilizer Lactofol, it positively influences the length of the spike, the difference was statistically significant, but least (LSD 5%). Lactofol has increased the length of the spike by 4,5%.

The self-application of foliar fertilizer increases the indicator number of grains in spike for the four varieties, but the difference is beyond statistical evidence. The action of the low nitrogen norm (N_6), alone and in combination with Lactofol, has proven positive effect on the Colorit variety, at LSD level of 1%, at Respect - from the lowest level - 5% and the other two varieties remains insignificant. The impact of the N_{12} on the number of grains in one spike has the highest statistical evidence for the standard only, with the Respect variety being proven at LSD of 1%, with Boomerang being of the lowest rank and Attila remaining insignificant. The same rate, combined with foliar fertilizers, is higher than the Colorit and Respect indicator at LSD 0,1 %, and Attila and Boomerang have the lowest evidence of impact. The application of N18 has the highest significance in Colorit and Respect, while Attila and Boomerang have a LSD level of 1%. The same nitrogen norm in combination with Lactofol is statistically proven in the four varieties of greatest significance.

Table 1.

Structural elements of the spike, with one-way (ANOVA) analysis of variance.

Varieties	Fertilization levels, kg/da	Spike length, cm	Number of grains in spike	Grain mass in spike, g	Mass of the spike, g	Harvest index
Colorit	N_0P_0	9,8	51,1	1,96	2,98	65,77
	N_0P_0 + lactofol	10,4^{NS}	60,4^{NS}	2,31^{NS}	3,36^{NS}	68,75^{NS}
	N_6P_6	10,9^{NS}	66,3**	2,54^{NS}	3,70^{NS}	68,65^{NS}
	N_6P_6 + lactofol	11,1^{NS}	68,0**	2,91**	3,99*	72,93***
	$N_{12}P_6$	11,8*	71,7***	3,01***	4,04*	74,50***
	$N_{12}P_6$ + lactofol	12,1**	73,9***	3,11***	4,15*	74,94***
	$N_{18}P_6$	12,4**	76,4***	3,28***	4,33**	75,75***
	$N_{18}P_6$ + lactofol	12,7***	79,7***	3,58***	4,66**	76,82***
Attila	N_0P_0	10,0^{NS}	47,5^{NS}	2,04^{NS}	3,14^{NS}	64,97^{NS}
	N_0P_0 + lactofol	10,7^{NS}	51,8^{NS}	2,42^{NS}	3,62^{NS}	66,85^{NS}
	N_6P_6	11,1^{NS}	54,3^{NS}	2,59*	3,99*	64,91^{NS}
	N_6P_6 + lactofol	11,5*	56,6^{NS}	2,74**	4,44**	61,71^{00}
	$N_{12}P_6$	12,6***	60,3^{NS}	2,95**	4,15*	71,08***
	$N_{12}P_6$ + lactofol	12,8***	62,6*	3,07***	4,47**	68,68^{NS}
	$N_{18}P_6$	13,0***	65,4**	3,20***	4,70**	68,09^{NS}
	$N_{18}P_6$ + lactofol	13,3***	69,4***	3,91***	5,51***	70,96***
Boomerang	N_0P_0	9,3^{NS}	49,2^{NS}	2,23^{NS}	3,13^{NS}	71,25***
	N_0P_0 + lactofol	10,3^{NS}	55,0^{NS}	2,44^{NS}	3,44^{NS}	70,93***
	N_6P_6	10,8^{NS}	58,4^{NS}	2,68**	3,78^{NS}	70,90***
	N_6P_6 + lactofol	11,0^{NS}	60,6^{NS}	2,82**	4,02*	70,15**
	$N_{12}P_6$	11,7*	61,6*	2,95**	4,35**	67,82^{NS}
	$N_{12}P_6$ + lactofol	12,0**	64,6**	3,18***	4,28**	74,30***
	$N_{18}P_6$	12,3**	66,9**	3,35***	4,65**	72,04***
	$N_{18}P_6$ + lactofol	12,5**	73,2***	3,78***	5,18***	72,97***
Respect	N_0P_0	9,6^{NS}	53,5^{NS}	2,05^{NS}	3,25^{NS}	63,08^{NS}
	N_0P_0 + lactofol	10,1^{NS}	55,9^{NS}	2,20^{NS}	3,60^{NS}	61,11^{000}
	N_6P_6	10,7^{NS}	61,5*	2,38^{NS}	3,98*	59,80^{000}
	N_6P_6 + lactofol	11,2^{NS}	64,3*	2,62*	4,42**	59,28^{000}
	$N_{12}P_6$	11,7*	67,1**	2,73**	4,03*	67,74^{NS}
	$N_{12}P_6$ + lactofol	11,9*	73,1***	2,91**	4,31**	67,52^{NS}
	$N_{18}P_6$	12,1**	76,6***	3,07***	4,57**	67,18^{NS}
	$N_{18}P_6$ + lactofol	12,6***	81,5***	3,44***	5,14***	66,93^{NS}
LSD	**5 %*	*1,6*	*10,1*	*0,6*	*0.9*	*3.2*
	***1%*	*2,1*	*13,4*	*0,7*	*1.2*	*3.8*
	****0,1 %*	*2,7*	*17,4*	*1,0*	*1.8*	*4.4*

*Positive * or negative ^{0} significance at P=5, 1 and 0,1%; ^{NS} – non significance*

From single action of the factors with the greatest significance is the nitrogen fertilization. All three fertilization norms have an impact on the research factor and are proven to the greatest extent of credibility. The lowest N_6 rate increases the number of grains in one spike by 15,4%, the rate of N_{12} increases by 26,0% and the highest N_{18} rate by 38,6%.

The self-acting of the foliar fertilizer is statistically significant with strong influence. Its significance is at LSD level of 1%, increasing the number of grains by 6,5% compared to variants without its application. In the indicator number of grains in one spike with high statistical significance, the differences in the genotype of the studied varieties are proved. With well-defined and significant differences of the highest rank, the varieties Attila and Boomerang stand out. The Respect remains with a difference of statistical significance and therefore has no significant impact.

For the Colorit and Respect varieties, the autonomic action of the nitrogen fertilizer on grain mass in spike is also not available, whereas for the Attila variety this effect is proved at LSD level of 5% and in the Boomerang variety at LSD level of 1%. Fertilization has a strong impact on the grain mass in spike. Fertilization with N_6 increased the grain mass in the spike by 20,4%, N_{12} by 35,3% and the rate of N_{18} by 56,1%.With the Lactofol foliar fertilizer acting alone, there is also a strong impact on the research factor. The impact of applied leaf fertilizer is proved to be of the highest rank, increasing the mass of the grains in the spike by 10,4% compared to the variants without its application.

The indicator mass of the spike follows the same trends described above for the grain mass in the spike.

Table 2.

Three-way (MANOVA) multivariate analysis of the factors

Factors / Soil fertilization		Spike length, cm	Number of grains in spike	Grain mass in spike, g	Mass of the spike, g	Harvest index
N_0P_0		10,0	53,1	2,21	3,32	66,59
N_6P_6		11,0**	61,3***	2,66***	4,04***	$66,04^{NS}$
$N_{12}P_6$		12,1***	66,9***	2,99***	4,22***	70,82***
N_{18} P_6		12,6***	73,6***	3,45***	4,84***	71,34***
LSD	*5 %*	*0,6*	*3,6*	*0,2*	*0,3*	*2,7*
	1 %	*0,7*	*4,7*	*0,3*	*0,4*	*3,5*
	0,1 %	*1,0*	*6,2*	*0,3*	*0,5*	*4,2*
Variety						
Colorit		11,4	68,4	2,84	3,90	72,27
Attila		$11,9^{NS}$	$58,5^{000}$	$2,87^{NS}$	4,25*	$67,16^{000}$
Boomerang		$11,2^{NS}$	$61,2^{000}$	$2,93^{NS}$	$4,10^{NS}$	$71,29^{NS}$
Respect		$11,2^{NS}$	$66,7^{NS}$	$2,66^{NS}$	$4,16^{NS}$	$64,08^{000}$
LSD	*5 %*	*0,6*	*3,6*	*0,2*	*0,3*	*2,7*
	1 %	*0,7*	*4,7*	*0,3*	*0,4*	*3,5*
	0,1 %	*1,0*	*6,2*	*0,3*	*0,5*	*4,2*
Foliar fertilization						
Untreated		11,2	61,7	2,69	3,92	68,35
Lactofol		11,7*	65,7**	2,97***	4,29**	$69,05^{NS}$
LSD	*5 %*	*0,4*	*2,5*	*0,1*	*0,2*	*2,2*
	1 %	*0,5*	*3,4*	*0,2*	*0,3*	*3,1*
	0,1 %	*0,8*	*4,4*	*0,2*	*0,4*	*3,9*

*Positive * or negative ^{0} significance at P=5, 1 and 0,1%; ^{NS} – non significance*

The differences in accumulation of biomass in two main parts of the spike – grains and glumes leading to their different ratio, expressed as a harvest index of the spike (HUCL AND GRAF, 1992).

When taking into consideration the independent impact of nitrogen fertilization on the triticale harvest index, the increase in nitrogen fertilization results in a higher percentage of grain relative to the straw. The exception is the lowest fertilizer rate $N_6P_{6,}$ where the harvest index value can be assumed to be equal to N_0P_0 due to the non-significant statistical difference. The highest harvest index was recorded for the Colorit and Boomerang varieties, with non-significant difference between them. The Attila and Respect varieties have a lower harvest index. Although the value of the harvest index for Lactofol treatment is higher than untreated variants, the application of foliar fertilizer had no statistically significant impact on spike harvest index in triticale.

CONCLUSIONS

The nitrogen fertilization is with great statistical significance to the length of the spike. Regarding the influence of the specificity of genotype, there is no reliable difference. Regarding single action of foliar fertilizer Lactofol, it positively influences the length of the spike.

The mineral fertilization has positive influence on the number of grains in one spike. The foliar fertilizer increases the number of grains by 6,5% compared to variants without its application. In the indicator number of grains in one spike, the differences in the genotype of the studied varieties are significant.

Fertilization has strong a impact on the grain mass in spike. With the Lactofol foliar fertilizer acting alone, there is also a strong impact on the research factor. The impact of applied leaf fertilizer is proved to be of the highest rank, increasing the mass of the grains in the spike by 10,4% compared to the variants without its application.

Increase in nitrogen fertilization results in a higher percentage of grain relative to the straw. The highest harvest index was recorded for the Colorit and Boomerang varieties. The Attila and Respect varieties have a lower harvest index. The application of foliar fertilizer had no statistically significant impact on spike harvest index in triticale.

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