



Nitrogen fertilization effect on grain yield and quality of spring triticale varieties

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ABSTRACT

The effect of fertilizing three triticale varieties (Timiryazevskaya, Karmen and Ukro) with nitrogen at different rates either one time at pre-sowing (N30, N 60, N90, N 120 and N150) or two times at pre-sowing and flowering stage (N90+ N30) and (N90+ N60) has been studied. The data indicated that all nitrogen treatments applied either at pre-sowing or/ and flowering stage resulted in a significant increase in triticale yield of three varieties (t/ha) compared to control. The highest yield in Timiryazevskaya (5.52 t/ha) was obtained after N120+N0 treatment, while in case of Karmen the highest yield (5.19 t/ ha) was obtained with N150+N0 fertilizing, as to Ukro the highest value (5.05 t/ ha) was noticed after N90+N30 treatment. Besides, the values of 1000 grains weight (gm) insignificantly increased in all cases. Protein and gluten percentage points grew simultaneously with increasing nitrogen amount.

Key words: Gluten, Nitrogen, Protein, Triticale, Yield.

INTRODUCTION

Triticale (*X Triticosecal wittmack*) is a hybrid cereal plant derived from wheat and rye genomes. It was produced to combine the grain qualities of wheat with the low input requirements and hardness of rye. According to statistical information of Food and Agriculture Organization (FAO, 2017), the world area under Triticale was about 4.165.783 hectares and world production reached 754.8 million tons.

Triticale grains have slightly lower content of fats (2.09%), proteins (13.05%), moisture (10.51%), than those of wheat (2.74; 13.68 and 10.94%) respectively. While the ash and total carbohydrates are higher in triticale grains (1.72% and 83.14%) than those of wheat grains (1.51% and 82.07%). Wheat flour has higher content of proteins (11.30%), carbohydrates (86.37%) than those of triticale (9.3% and 85.45% respectively) (Hammad (2012).

Triticale cultivars, grown for forage as well as for grains, can be classified into three basic types: spring, winter, and intermediate (facultative). Spring types exhibit upright growth and produce much forage early in their growth. They are generally insensitive to photoperiod and have limited tillering (Mergoum *et al.*, 2004).

Nitrogen is undoubtedly the key factor determining cereal yield to the greatest degree. This element modifies both the yield of cereal chemical composition and the grain feed value (Wróbel 2005 and Knapowski *et al.*, 2010). Yield increased with higher N application which proved the fact that N is an important constituent of nucleotides, proteins,

chlorophyll and enzymes, involving in various metabolic processes which have a direct impact on vegetative and reproductive phases of plants (Chaturvedi, 2006). A Nitrogen dose rate improved grain quality of wheat by significant increase in protein content, hectolitre weight, sedimentation value in nitrogen treatment applied compared to control. This increase in protein content with an increase in the nitrogen dose is due to the fact that nitrogen is the constituent of different amino acids forming different types of protein in wheat grain (Kumar *et al.*, 2018).

Katarzyna *et al.*, (2015) reported that nitrogen fertilization doses and the years of research influenced the grain and protein yield. The highest grain and protein yield of Milewo variety of spring triticale was obtained after the application of nitrogen fertilization at the rate of 120 kg ha⁻¹. Lestingi *et al.*, (2010) proved that the nitrogen rate for ensuring good triticale grain quality is ca. 50 kg ha⁻¹. Under this rate, grain and protein yield increased by 14.2% and 25.0%, respectively. While Janus`auskaite` (2013) found that nitrogen rate of 90–120 kg ha⁻¹, under which grain yield increased by 33.9 and 37.0%, respectively, compared to the object without fertilization, proved optimally economical practice for achieving high spring triticale grain yield. The positive effect of higher nitrogen rates, 160–180 kg ha⁻¹, was confirmed in research by Cimrin *et al.*, (2004) and Mut *et al.*, (2005) high grain yield and protein concentration of nitrogen-fertilized spring triticale in the rate range of 90–120 kg ha⁻¹ was confirmed by the research of Spychaj-Fabisiak *et al.*, (2005).

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MATERIALS AND METHODS

To study the impact of fertilizing spring triticale varieties (Timiryazevskaya, Karmen and Ukro) with nitrogen on grain yield and quality an experiment was conducted during three successive spring seasons of 2016, 2017 and 2018 at the Field Experimental Station of the Russian State Agrarian University – Moscow Agricultural Academy named after KA Timiryazev in medium loam soils, the latter being characterized by an average abundance of humus — 1.9 %, P_2O_5 — 283.0 mg/kg, K_2O — 134 mg/kg; pH_{KCl} — 4.8.

Nitrogen fertilizers were applied in the form of ammonium nitrate (NH_4NO_3) and split into two doses, the

first dose was applied pre-sowing from N_{30} to N_{150} kg /ha, while the second dose was applied at the flowering stage at N_{30} and N_{60} kg /ha.

The experiment was performed using a complete random design with eight treatments

1. Control (N_0),
2. N_{30} (pre-sowing) + N_0 ,
3. N_{60} (pre-sowing) + N_0 ,
4. N_{90} (pre-sowing) + N_0 ,
5. N_{120} (pre-sowing) + N_0 ,
6. N_{150} (pre-sowing) + N_0 ,
7. N_{90} (pre-sowing) + N_{30} (at flowering stage GS55)
8. N_{90} (pre-sowing) + N_{60} (at flowering stage GS55)

Table 1: Weather conditions during seasons studies.

Months	Temperature °C			Precipitation mm		
	2016	2017	2018	2016	2017	2018
April	8.30	5.40	8.00	10.70	24.90	12.60
May	1.90	11.00	16.10	18.40	26.10	22.40
June	18.20	14.30	17.20	17.20	38.40	19.50
July	20.90	17.80	20.30	36.10	34.20	28.40
August	19.50	18.90	19.80	50.70	25.60	6.60

Table 2: Effect of fertilizing (Timireazevskaya, Karmen and Ukro) triticale with different doses of nitrogen on yield (t/ha⁻¹) during (2016, 2017 and 2018) seasons.

Treatments	2016	2017	2018	Average
Timiryazevskaya				
Control	3,00	3,11	4,36	3,50
$N_{30}+N_0$	3,62	3,41	5,13	4,04
$N_{60}+N_0$	4,33	4,92	5,60	4,94
$N_{90}+N_0$	4,53	4,99	5,45	5,01
$N_{120}+N_0$	5,26	5,52	5,80	5,52
$N_{150}+N_0$	4,49	5,76	6,01	5,43
$N_{90}+N_{30}$	4,59	4,88	6,40	5,30
$N_{90}+N_{60}$	4,60	5,80	5,30	5,23
LSD ₀₅	0,86	1,31	1,13	1,25
Karmen				
Control	2,75	3,84	3,88	3,49
$N_{30}+N_0$	3,70	4,47	4,42	4,20
$N_{60}+N_0$	3,79	4,99	4,23	4,33
$N_{90}+N_0$	4,41	4,70	5,07	4,73
$N_{120}+N_0$	4,35	4,76	4,64	4,58
$N_{150}+N_0$	4,01	5,76	5,80	5,19
$N_{90}+N_{30}$	4,44	5,16	5,71	5,10
$N_{90}+N_{60}$	4,27	4,97	4,79	4,68
LSD ₀₅	0,65	0,92	0,94	1,01
Ukro				
Control	3,86	3,13	4,07	3,69
$N_{30}+N_0$	4,76	3,30	4,62	4,23
$N_{60}+N_0$	4,99	3,62	3,86	4,16
$N_{90}+N_0$	5,10	3,81	3,83	4,25
$N_{120}+N_0$	5,83	3,97	4,97	4,92
$N_{150}+N_0$	5,68	4,85	4,55	5,03
$N_{90}+N_{30}$	5,15	4,81	5,18	5,05
$N_{90}+N_{60}$	4,68	3,86	4,02	4,19
LSD ₀₅	0,81	1,06	1,12	1,13

Therefore, each treatment was replicated three times. The area of each plot was 5 m², 5 m in length and 1 m in width, the seeding rate was 4.5 million seeds/ha.

Meteorological conditions in the years of research 2016-2018 were presented according to the data of V.A. Michelson meteorological observatory based on RSAU-Moscow Agricultural Academy named after K.A. Timiryazev. which differed in temperature, the amount of precipitation, as well as their distribution by decades and months of the growing season of the spring triticale Table 1.

The measurements:

1. **Grains yield/ hectare (10000 m²):** The experimental plots (5m²) were harvested and threshed and the grains were weighed and then converted to the weight of grains/hectare.
2. **1000 grains weight:** It was determined according to GOST 10842-89 Cereals, pulses and oilseeds. Method for determination of 1000 kernels or seeds weight.
3. **Protein, gluten:** These were determined according to GOST R 54478-2011 Grain. Methods for determination of quantity and quality of gluten in wheat.

Statistical analyses: The data were subjected to analysis of variances (ANOVA) according to Dospekhov, (1985). Least significant ranges (LSR) were used to compare meanings of treatments according to Duncan, (1955) at the probability of 5%.

RESULTS AND DISCUSSION

The data in Table 2 show the effect of different doses of nitrogen fertilizing on the yield of three triticale varieties (Timireazevskaya, Karmen and Ukro) during the years of study.

The results indicate that there was a significant increase in yield in three triticale varieties (t/ha) when nitrogen fertilizer was applied compared to control during the years of study.

By looking into the matter of the combined analysis, it could be seen that the increase in Timireazevskaya yield reached about 57.7% compared to control, when triticale was treated with (N120+N0), but in Karmen variety the increase in yield was 32.8% compared to control, when the crop was treated with (N150+N0), while in Ukro variety the

Table 3: Effect of fertilizing (Timireazevskaya, Karmen and Ukro) triticale with different doses of nitrogen on 1000 grains weight (gm) during (2016, 2017 and 2018) seasons.

Treatments	2016	2017	2018	Average
Timiryazevskaya				
Control	46,38	48,30	46,65	47,11
N ₃₀ +N ₀	46,82	48,30	46,55	47,22
N ₆₀ +N ₀	46,35	49,65	47,25	47,75
N ₉₀ +N ₀	50,85	47,25	45,68	47,93
N ₁₂₀ +N ₀	48,75	48,33	46,48	47,85
N ₁₅₀ +N ₀	48,32	51,17	46,93	48,81
N ₉₀ +N ₃₀	49,67	48,88	47,90	48,82
N ₉₀ +N ₆₀	48,18	48,60	48,05	48,28
LSD ₀₅	3,10	2,87	2,41	2,67
Karmen				
Control	47,53	47,23	47,65	47,47
N ₃₀ +N ₀	47,03	47,97	46,92	47,30
N ₆₀ +N ₀	48,07	46,08	47,10	47,08
N ₉₀ +N ₀	47,93	44,65	48,00	46,86
N ₁₂₀ +N ₀	51,08	46,48	46,60	48,05
N ₁₅₀ +N ₀	51,65	47,15	50,62	49,81
7.N ₉₀ +N ₃₀	53,42	46,35	49,68	49,82
N ₉₀ +N ₆₀	51,07	45,13	50,13	48,78
LSD ₀₅	4,90	3,18	2,75	3,85
Ukro				
Control	46,05	48,55	46,17	46,92
N ₃₀ +N ₀	46,83	50,75	48,10	48,56
N ₆₀ +N ₀	45,92	48,47	47,70	47,36
N ₉₀ +N ₀	50,20	50,03	45,70	48,64
N ₁₂₀ +N ₀	49,50	50,38	46,60	48,83
N ₁₅₀ +N ₀	48,35	50,83	47,60	48,93
N ₉₀ +N ₃₀	50,15	49,50	47,63	49,09
N ₉₀ +N ₆₀	50,48	49,30	47,20	48,99
LSD ₀₅	3,39	3,42	2,84	3,10

increase was 36.9 and 36.3% compared to control, when it was treated with (N90+N30) and (N150+N0), respectively.

This result agreed with the data reported by Cimrin *et al.*, (2004) and Mut *et al.*, (2005) Spychaj-Fabisiak *et al.*, (2005) and Janušauskaitė, (2008) who found that a grain yield increase of 19.5–24.0 % was obtained due to nitrogen fertilizer application. Knapowski *et al.*, (2009); Lestingi *et al.*, (2010); Janus`auskaite` (2013) and Katarzyna *et al.*, (2015) found as well that the nitrogen fertilization rate and the years of research affected grain yield. The highest grain yield of Milewo variety spring triticale was obtained after the application of nitrogen fertilization at the rate of 120 kg ha⁻¹.

The data in Table 3 indicated the fertilizing impact on three triticale varieties (Timireazevskaya, Karmen, and Ukro), fertilization being applied with different doses of nitrogen on 1000 grains weight during 2016, 2017 and 2018.

It could be noticed that, application of nitrogen fertilizer has resulted in increase in the 1000 seeds weight, this increase being not significant in most treatment cases

for three years. Concerning the combined analysis, the data show that the 1000 grains weight (gm) was not affected by adding nitrogen either at pre-sowing or/ and flowering stage. This effect was obvious for three varieties of triticale.

This finding was similar to Abou-Warda and Sadeq (1994), Rozbicki (1994), Hassaan (2003) who showed that increasing nitrogen fertilization level up to 110 kg/fed significantly increased triticale 1000 kernel weight.

Results in Table 4 make it clear that, in general, triticale varieties treated with nitrogen at both growing stages demonstrated increase of grain protein content.

Concerning Timireazevskaya variety, it to observed from the data that treatment with N at the rate of 150kg/ha either once at the pre-swing stage (N₁₅₀) or twice at both stages (pre-swing and flowering) (N₉₀+ N₆₀) gave the maximum protein percentage rise for three years of study, this increase reached about 14.73 and 17.83% over the control in 2016, while the increase in 2017 was about 12.73 and 15.45% over the control after two treatments respectively. Moreover, in 2018 the increases were 18.85 and 22.13% over the control correspondingly.

Table 4: Effect of fertilizing (Timireazevskaya, Karmen and Ukro) triticale with different doses of nitrogen on protein percentage rise (%) during (2016, 2017 and 2018) seasons.

Treatments	2016	2017	2018	Average
Timiryazevskaya				
Control	12,90	10,97	12,22	12,03
N ₃₀ +N ₀	12,58	10,89	12,56	12,01
N ₆₀ +N ₀	12,92	10,92	13,14	12,32
N ₉₀ +N ₀	14,01	11,26	13,49	12,92
N ₁₂₀ +N ₀	14,16	11,32	14,05	13,18
N ₁₅₀ +N ₀	14,76	12,43	14,46	13,88
N ₉₀ +N ₃₀	14,32	11,42	14,12	13,29
N ₉₀ +N ₆₀	15,23	12,71	14,88	14,27
LSD ₀₅	0,60	1,03	0,88	2,31
Karmen				
Control	13,29	11,34	12,66	12,43
N ₃₀ +N ₀	12,78	11,42	12,85	12,35
N ₆₀ +N ₀	13,16	11,72	14,11	13,00
N ₉₀ +N ₀	13,89	12,45	14,92	13,75
N ₁₂₀ +N ₀	14,90	12,41	15,58	14,30
N ₁₅₀ +N ₀	15,89	12,81	15,27	14,66
N ₉₀ +N ₃₀	14,91	12,11	15,44	14,15
N ₉₀ +N ₆₀	15,06	13,54	15,79	14,80
LSD ₀₅	0,85	0,66	1,12	2,30
Ukro				
Control	13,29	11,76	12,13	12,39
N ₃₀ +N ₀	12,78	11,89	14,34	13,00
N ₆₀ +N ₀	13,27	11,90	15,43	13,53
N ₉₀ +N ₀	13,89	12,18	14,34	13,47
N ₁₂₀ +N ₀	14,90	12,72	14,72	14,11
N ₁₅₀ +N ₀	15,89	13,36	14,21	14,49
N ₉₀ +N ₃₀	14,91	12,27	14,83	14,00
N ₉₀ +N ₆₀	14,99	12,87	13,81	13,89
LSD ₀₅	0,94	0,77	2,27	2,19

As to Karmen variety, the data also showed that Karmen triticale treated with N_{150} and $N_{90} + N_{60}$ gave the highest percentage rise of grain protein content. Regarding the combined statistical analysis, the results showed that these two treatments resulted in about 18.55% and 19.53% grain protein percentage rise in contrast to control respectively.

In relation to Ukro variety, the highest percentages rise of grain protein (19.55% and 13.56 against control) were reported when Ukro triticale was treated with N_{150} at pre-swing in the first and second seasons, while in the third season the highest percentage rise (22.31% over the control) was observed after $N_{90} + N_{30}$ application.

The protein content in cereal grains depends upon the genotype and environmental factors, mainly temperature, moisture, soil fertility, and N fertilization (Rao, *et al.*, (1993)).

The research findings about nitrogen treatment impact on triticale protein percentage rise coincide with that of Cimrin *et al.*, (2004); Kaur *et al.* (2008); Mut *et al.*, (2005); Kharub and Chander, (2010) and Lestingi *et al.*, (2010) who noticed that nitrogen application at different rates influenced

triticale grain protein content significantly and this percentage rise was increased markedly up to 160 kg N.ha⁻¹.

The combined data of three seasons' studied (Table 5) represent the fact that, in general, treatment of triticale with nitrogen at different doses either once at the pre-swing stage or twice at pre-swing and flowering stages results in significant gluten percentage rise.

Regarding Timireazevskaya variety the gluten percentage index was increased from 13.2% to 18.6% under different doses of nitrogen, while this range in Karmen variety was increased from 14.5 % to 20.1%, however in Ukro variety this index was increased from 14.7% to 19.8%.

Both gluten quantity and quality are responsible for dough viscoelastic properties, the production of a large variety of leavened and unleavened bread depending on them.

The confounding factor of protein content must be considered as part of an equitable analysis of gluten quality in cultivar breeding, in the interpretation of previous triticale research and in comparison analyses of wheat and triticale. Hence improved gluten properties will expand the utility of

Table 5: Effect of fertilizing (Timireazevskaya, Karmen and Ukro) triticale with different doses of nitrogen on gluten percentage rise (%) during (2016, 2017 and 2018) seasons.

Treatments	2016	2017	2018	Average
Timiryazevskaya				
Control	15,84	9,66	14,02	13,17
$N_{30} + N_0$	16,08	9,58	15,04	13,57
$N_{60} + N_0$	17,83	9,52	16,46	14,60
$N_{90} + N_0$	19,33	10,78	17,09	15,73
$N_{120} + N_0$	20,38	10,91	18,61	16,63
$N_{150} + N_0$	20,57	13,19	19,28	17,68
$N_{90} + N_{30}$	21,00	11,02	18,54	16,85
$N_{90} + N_{60}$	20,54	14,40	20,77	18,57
LSD ₀₅	1,72	2,67	2,44	7,31
Karmen				
Control	16,70	11,42	15,45	14,52
$N_{30} + N_0$	15,21	11,55	15,42	14,06
$N_{60} + N_0$	16,26	12,52	18,25	15,68
$N_{90} + N_0$	18,09	14,37	20,02	17,49
$N_{120} + N_0$	20,54	14,18	21,93	18,88
$N_{150} + N_0$	23,07	14,99	21,16	19,74
$N_{90} + N_{30}$	20,89	13,41	21,41	18,57
$N_{90} + N_{60}$	21,23	16,83	22,20	20,09
LSD ₀₅	2,05	1,57	2,71	5,88
Ukro				
Control	16,70	13,26	14,11	14,69
$N_{30} + N_0$	15,21	13,43	19,24	15,96
$N_{60} + N_0$	16,67	13,40	21,86	17,31
$N_{90} + N_0$	18,09	14,02	19,24	17,12
$N_{120} + N_0$	20,54	15,34	20,22	18,70
$N_{150} + N_0$	23,07	17,24	18,97	19,76
$N_{90} + N_{30}$	20,89	14,22	20,49	18,53
$N_{90} + N_{60}$	20,98	16,18	18,04	18,40
LSD ₀₅	2,33	2,00	5,48	5,32

triticale in human food products and, thus, increase potential profitability of triticale production. Pattison *et al.*, (2014).

CONCLUSION

Three varieties of spring triticale treated with nitrogen at different doses either once at the pre-swing stage

or twice during pre-swing and flowering stages have demonstrated a significant increase in grain yield, protein and gluten content. In order to obtain the highest yields with high quality, it is recommended to apply a nitrogen dose at 150 kg/ha at the pre-sowing stage.

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