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Effect of Nitrogen Fertilization on Protein Yield and Nutrient Uptake in Some Triticale Genotypes

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Abstract: This study was carried out to determine the effect of different rates of nitrogen (0, 40, 80, 120, 160 kg ha^{-1}) and four triticale genotypes (xTriticosecale Wittmack) on uptakes and contents of N, P, K, Ca, Mg, Fe, Cu, Zn and Mn together with protein yield of triticale under the conditions of Van. Nitrogen fertilizer significantly increased the grain protein yield, grain and straw N contents, straw P and Mn contents and N, P, K, Ca, Mg, Fe, Cu, Zn and Mn uptakes of grain and straw. The uptakes of triticale genotypes with different nitrogen fertilization were observed between 30.3 and 64.9 kg N ha^{-1}, 7.4 kg and 14.4 kg P ha^{-1}, 42.9 kg and 79.4 kg K ha^{-1}, 4.5 kg and 8.2 kg Ca ha^{-1}, 2.4 kg and 4.3 kg Mg ha^{-1}, 410 g and 780 g Fe ha^{-1}, 42 g and 83 g Cu ha^{-1}, 46 g and 81 g Zn ha^{-1} ve 186 g and 316 g Mn ha^{-1} .

Key words: Triticale, nitrogen, genotype, protein yield, nutrient content, nutrient uptake

INTRODUCTION

Cereals are the world's major crop in terms of food production. In addition to being essential for the human diet, they are also the most important input for the fodder industry. A new cereal crop was developed in the 1960's, named triticale, which had a high nutrient value and better yield than other cereals under unfavourable conditions such as drought and cold. Triticale is a cross between wheat and rye. It was reported that triticale gave higher yields than wheat in some regions having very hard winters with shallow soils[1,2]. In The East Anatolian Region, nearly whole area sown is used for cereal grain production[3]. The amount of forage needed can not be produced in this region although livestock is the main income for the people.

In some studies conducted with triticale showed that the digestibility of this crop was lower than that of maize, equal to of wheat and higher than of barley and it was suggested that triticale could be replaced with barley for animal feeding and that it had an advantage of having a good balance of amino acid[4]. Lorenz[5] cited that triticale grains contained higher amount of P, Mg, Mn, Fe and Cu than wheat. This region suffers from, very hard and long winters followed by a long period of drought resulting in a serious reduction in cereal yield, the yield even being lower than the average of the country. Yilmaz and Bostan[6], compared their findings with results of some experiments performed under different ecological conditions. They explained that the yields were lower than the others but triticale was found to be the highest yielded one among the cereals.

The objective of this study was to find out the effects of different nitrogen rates to the protein yield of different triticale genotypes and the contents and uptakes of N, P, K, Ca, Mg, Fe, Cu, Zn and Mn.

MATERIALS AND METHODS

The experiment was conducted at the experimental field of Agricultural Faculty, Yüzüncü Yil University in 1995-1996. The soil characteristics were presented in Table 1. The analysis for these characteristics were; texture, Bouyoucous hydrometer[7], pH, Jackson[8], lime ($CaCO_3$), Allison and Moodie[9], organic matter modified Walkley Black method[10], total salt conductivity of saturated mud extract[11], available P, sodium bicarbonate method for[12] and exchangeable K[13].

The soil had a sandy-loam and sandy-clay-loam texture. It was low in organic matter and available P with excessive lime, having light salt problem and moderate exchangeable potassium[14].

The trial was arranged as a factorial randomized block design combining five nitrogen fertility levels, four genotypes and four replicates, in plots with eight-row 6 m long, 0.20 m between rows. The unit area was 1.6x6 m = 9.6 m^2.

The pedigree numbers and origins of the four genotypes are given in Table 2. The nitrogen treatments were 0, 40, 80, 120 and 160 kg N ha^{-1}.

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Table 1: Soil characteristics of experimental field

Depth cm	Texture	pH	$CaCO_3$ (%)	Organic matter (%)	Total salt (%)	Avai. P (ppm)	Ex. K (ppm)
0-20	Sandy-loam	7.69	14.27	0.57	0.410	4.92	253.0
20-40	Sandy-clay-loam	7.83	15.41	0.41	0.018	2.72	187.0

Table 2: Pedigree numbers and origins of the triticale genotypes

Genotype	Pedigree	Origins
7	DRIRA OUT CROSx21295 OAP9	ICARDA
9	YOGU 1 “S”/ANTEATER 62 CTM 10403-015M OY 2B BY OB	CMMYT
10	JUANILLO 98-212 OAP	ICARDA
13	HARE 7265/YOGU 1 “S” SWT 1697 05Y-OM OY4M-1YP-OB	CMMYT

The fertilisation was applied in the form of ammonium sulphate containing 21% N, half during the preparation of the soil, and the other half at the start of tillering. Additionally, same amount of phosphate to all plots was applied at the rate of 80 kg P_2O_5 ha^{-1}.

Grain and straw samples were collected before harvest and subjected to drying in oven at 70°C until their weight became unchanged. On dried and milled plant samples the total N was measured by using Kjeldahl method while extracted samples were used for N, P, K, Ca, Mg, Fe, Cu, Zn and Mn analysis according to Kacar[15]. The rate of grain nitrogen was multiplied with 5.7 and with grain yield to get protein yield.

The annual rainfall was 366.3 and 389.4 mm in 1995 and 1996, respectively. Mean temperatures were 9.7°C in 1995 and 10.3°C in 1996. The long-term average of rainfall is 384 mm and that of mean temperature is 8.8°C.

Data was evaluated by using analysis of variance and the significance between mean values were expressed by Duncan’s Multiple Range Test[16] .

RESULTS AND DISCUSSION

Protein yields, N, P, K uptakes and contents of triticale genotypes under different nitrogen treatments are presented in Table 3. Nitrogen fertilization significantly increased protein yield of triticale. The lowest protein yield was for control, no nitrogen treatment, with 133.4 kg ha^{-1} whilst the highest value was 260.5 kg ha^{-1} at 120 kg N level. Protein yield did not significantly increase beyond 80 kg N ha^{-1}.

There were no significant differences among genotypes for protein yields. However, there was a significant nitrogen x genotype interactions (Table 4). Genotype 13 gave the greatest response to nitrogen having the lowest protein yield (111.0 kg ha^{-1}) with out nitrogen and the highest protein yield, 304.3 kg ha^{-1}, with 120 kg ha^{-1} N.

Nitrogen applications significantly increased grain N concentration (%) and total (grain+straw) N uptake. Comparing to control treatment, increase in N doses resulted in increase in N concentration of grain, but all applications excluding control placed in the same group according to Duncan’s Test results. There was a significant associated with genotypes for grain N content was genotype 9 being significantly lower from the other three genotypes. The highest grain N content (2.25%) was by genotype 10 when 120 kg ha^{-1} g N was applied and the lowest N content (1.54%) from genotype 7 when out nitrogen emphasized significant nitrogen x genotype interactions. The lowest straw nitrogen concentration was obtained from the control (0.27%), the highest (0.40%) from 120 kg ha^{-1} nitrogen treatment. Ellen[17] in studies with triticale, wheat, barley and oats found a similar straw N content (0.30%) for all cereals. In this study, total N uptake varied from 30.3 kg ha^{-1} in control to 64.9 kg ha^{-1} in the 120 kg ha^{-1} N treatment (Table 3). The largest N uptake from the soil was recorded for genotype 13 (75.8 kg ha^{-1}) with the application of 120 kg ha^{-1} nitrogen (Table 4). The lowest N uptake for all genotypes were with no nitrogen application. In some studies conducted under different ecological conditions[18-20], it was reported that nitrogen fertilization caused significant increases in both the content and uptake of nitrogen of grain and also of straw. These results seem to contrast with that of Isfan *et al.*[21] who reported that there were no significant differences among triticale genotypes for nitrogen uptake[22].

There was no significant effect of nitrogen fertilization on grain phosphate content irrespective of genotypes. On the contrary, straw P content increased significantly with nitrogen application. Straw P content being the lowest in control with a value of 0.066% reached that of 0.089% with 160 kg ha^{-1} nitrogen application, but all levels of application set up the same Duncan’s group with the exception of control, no treatment. The effects of N fertilization, genotype and nitrogen x genotype interactions were significant on total P uptake. The total (grain+straw) P uptake approximately was doubled with N application. Genotype 7 had the lowest value followed by genotype 10, both of which were significantly different from genotype 9. Genotype 13 was found to have the largest P uptake (17.1 kg) under 120 kg N treatment, but it had the lowest value (5.9 kg ha^{-1}) when unfertilized. This contrast points the significant nitrogen x genotype interactions.

Table 3: Protein yields, N, P, K uptake and contents of four triticale genotypes grown under different nitrogen treatments

		N+			P			K		
Nitrogen dose (kg N ha^{-1})	Grain Protein yield (kg ha^{-1})	Grain content (%)	Straw content (%)	Grain+Straw uptake (kg ha^{-1})	Grain content (%)	Straw content (%)	Grain+Straw uptake (kg ha^{-1})	Grain content (%)	Straw content (%)	Grain+Straw uptake (kg ha^{-1})
0	133.4b	1.63b	0.27c	30.3d	0.43	0.066b	7.4c	0.66	1.27	42.9c
40	163.7b	1.85a	0.35b	41.0c	0.40	0.083a	9.2b	0.65	1.25	53.0b
80	231.8a	1.88a	0.35b	56.8b	0.45	0.091a	14.4a	0.66	1.23	73.3a
120	260.5a	1.92a	0.40a	64.9a	0.43	0.088a	14.4a	0.66	1.29	76.1a
160	240.2a	1.90a	0.37ab	60.9ab	0.43	0.089a	13.9a	0.66	1.24	79.4a
Genotype										
7	193.3	1.84a	0.348	48.4	0.40	0.081	10.9b	0.67	1.25	62.6
9	201.4	1.73b	0.336	50.0	0.44	0.087	13.0a	0.66	1.27	68.8
10	218.5	1.92a	0.349	52.3	0.44	0.078	11.4b	0.66	1.24	62.5
13	210.6	1.86a	0.365	52.4	0.44	0.088	12.1ab	0.66	1.27	65.9
Nitrogen F	20.73***	8.95**	9.56***	43.9***	2.01	4.21**	34.3***	0.21	2.33	21.00***
Genotype F.	1.05	5.32**	0.77	0.93	2.70	1.15	3.19*	1.09	2.40	0.94
NXG.int. F.	2.05*	3.79***	0.82	2.85**	0.09	1.04	2.14*	0.85	1.02	1.01

*, ** and *** significant at $p<0.05$, $p<0.01$ and $p<0.001$ levels, respectively. The means values by different letter(s) are significant ($p<0.05$)
+(Bozkurt, M.A., K.M. Çimrin, N. Şekeroğlu[22])

Table 4: Nitrogen x genotype interactions

N X Gen. Int.	Grain protein yield (kg ha^{-1})	Grain N content (%)	Grain+Straw N uptake (kg ha^{-1})	Grain+Straw P uptake (kg ha^{-1})	Grain+Straw Mg uptake (kg ha^{-1})
N_0 Gen 7	142.8fg	1.54h	29.8h	7.5hi	2.4gh
N_0 Gen 9	137.5fg	1.66f-h	32.3h	8.5hi	2.4gh
N_0 Gen 10	142.2f-g	1.64gh	32.6h	7.8hi	2.5f-h
N_0 Gen 13	111.0g	1.68e-h	26.8h	5.9i	2.2h
N_4 Gen 7	193.5c-f	2.14ab	48.1e-g	8.5hi	3.3e-g
N_4 Gen 9	151.7fg	1.71e-h	38.2f-h	9.9f-h	2.8f-h
N_4 Gen 10	161.6e-g	1.88c-h	41.2f-h	9.3g-I	2.8f-h
N_4 Gen 13	148.2fg	1.68e-h	36.5gh	8.8g-I	2.8f-h
N_8 Gen 7	210.8b-f	1.83c-g	52.3c-f	14.0a-e	3.4d-f
N_8 Gen 9	195.0c-f	1.77d-h	50.4d-g	13.1c-f	3.8c-e
N_8 Gen 10	272.6a-c	1.91b-f	60.3b-e	14.7a-e	4.1b-e
N_8 Gen 13	248.6a-d	1.98b-d	64.4a-d	15.7a-d	4.3a-d
N_{12} Gen 7	175.6d-g	1.76d-h	47.2e-g	11.2e-h	3.8c-e
N_{12} Gen 9	275.5ab	1.80c-h	66.4a-c	16.9ab	4.4a-c
N_{12} Gen 10	286.4ab	2.25a	70.2ab	12.2d-g	4.2a-e
N_{12} Gen 13	304.3a	1.87c-g	75.8a	17.1a	4.8ab
N_{16} Gen 7	243.4a-d	1.94b-e	64.7a-d	13.0c-f	4.5a-c
N_{16} Gen 9	246.8a-d	1.69e-h	63.1a-d	16.2abc	5.1a
N_{16} Gen 10	229.5a-e	1.94b-e	57.2b-e	13.3b-f	3.9b-e
N_{16} Gen 13	241.0a-d	2.04a-c	58.5b-e	13.0c-f	3.8c-e

The means values by different latter(s) are significant ($p<0.05$)

Table 5: Ca, Mg and Fe contents and uptakes of triticale genotypes under different nitrogen treatments

	Ca			Mg			Fe		
Nitrogen dose (kg N ha^{-1})	Grain content (mg kg^{-1})	Straw content (mg kg^{-1})	Grain+Straw uptake (kg ha^{-1})	Grain content (mg kg^{-1})	Straw content (mg kg^{-1})	Grain+Straw uptake (kg ha^{-1})	Grain content (Mg kg^{-1})	Straw content (mg kg^{-1})	Grain+Straw uptake (kg ha^{-1})
0	309	1540	4.5b	847	448	2.4c	56	129	410b
40	285	1450	5.5b	858	458	3.0b	60	128	540b
80	305	1420	7.4a	882	427	3.9a	64	121	710a
120	312	1500	7.6a	876	470	4.3a	71	124	740a
160	316	1470	8.2a	873	457	4.3a	66	120	780a
Genotype									
7	309	0.152	6.6	856	473	3.5	65	111	570b
9	296	0.148	7.0	870	435	3.7	68	139	740a
10	305	0.138	6.2	879	447	3.5	61	127	620b
13	312	0.152	6.8	862	454	3.6	61	122	610b
Nitrogen F	0.60	0.95	11.60**	1.27	2.22	36.00***	0.18	1.52	12.3***
Genorype F.	1.56	0.40	0.70	1.59	1.36	0.59	1.18	0.78	3.59*
NXG.int. F.	1.83	0.97	1.17	1.79	0.86	2.10*	1.12	1.12	1.07

The means values by different letter(s) are significant ($p<0.05$)

Table 6: Cu, Zn and Mn contents and uptakes of triticale genotypes under different nitrogen treatments

	Cu			Zn			Mn		
Nitrogen dose (kg N ha^{-1})	Grain content (mg kg^{-1})	Straw content (mg kg^{-1})	Grain+Straw uptake (kg ha^{-1})	Grain content (mg kg^{-1})	Straw content (mg kg^{-1})	Grain+Straw uptake (kg ha^{-1})	Grain content (Mg kg^{-1})	Straw content (mg kg^{-1})	Grain+Straw uptake (kg ha^{-1})
0	12.7	8.9	42c	14.1	9.3	46b	48.7	43a	186c
40	17.2	10.4	63b	15.4	8.0	53b	51.3	43a	232bc
80	16.4	9.6	83a	16.7	9.0	81a	56.6	34b	281ab
120	17.1	10.4	92a	15.5	7.8	76a	56.0	38ab	316a
160	15.0	12.3	97a	17.5	7.5	77a	52.5	36b	304a
Genotype									
7	15.5	8.7 b	65b	17.3	8.2	65	52.9	39	254
9	15.2	10.7 ab	72ab	15.0	9.6	76	52.3	38	275
10	17.5	12.4 a	87a	16.5	8.2	62	53.7	40	260
13	14.7	9.4 b	72ab	14.7	8.9	65	53.3	38	267
Nitrogen F	1.29	2.11	14.40***	0.82	0.84	7.94***	0.85	2.99*	9.00***
Genotype F.	0.64	4.39**	2.89*	0.93	1.06	1.50	0.04	0.18	0.33
NXG.int. F	1.47	0.37	1.34	0.87	1.23	1.18	0.96	1.59	1.32

The means values by different letter(s) are significant ($p<0.05$)

Grain and straw potassium (K) contents were not affected by nitrogen fertilization. Similarly, it was found that the effects of genotype and nitrogen x genotype interactions on grain+straw K contents were not significant. Conversely, nitrogen had significant effect on grain+straw K uptake. Duncan's Test results showed that control treatment constituted the lowest group with 42.9 kg ha^{-1} while 40 kg ha^{-1} application was placed in another group with 53.0 kg ha^{-1} K uptake. The other two treatments with increasing values were included in the same group. These findings are in agreement with some other results which suggested that nitrogen fertilization caused increase in contents and uptakes of N, P and K of triticale and some other cereals[19,23,24].

Different levels of nitrogen applications and genotypes effects on triticale grain and straw contents of Ca, Mg and Fe and Ca, Mg and Fe uptakes of grain+straw were given in Table 5.

Increased doses of nitrogen caused significant increase in only grain+straw Ca uptake of triticale plants. There was no significant differences among genotypes for Ca content and uptake whilst genotype x nitrogen interactions did not appear for these traits. The amounts of Ca uptakes were 4.5 and 5.5 kg ha^{-1} of control and 40 kg ha^{-1} N treatment, respectively, the former of which made up the lower ranking group according to the Duncan's test while the other three treatments were placed in the higher group with 7.4, 7.6 and 8.2 kg ha^{-1} Similar results were obtained for Mg contents of grain and straw and grain+straw uptake, for the latter nitrogen fertilization produced a positive and significant effect. Mg uptake was the lowest in control; it increased linearly with N application and reached 4.3 kg ha^{-1}. Nitrogen x genotype interactions were also significant, genotype 9 had the largest Mg uptake with 160 kg ha^{-1} nitrogen application, but it was not at the top in control in which genotype 13 had the lowest Mg uptake.

Genotypes and fertilisation did not affect grain and straw Fe contents. On the contrary, grain+straw Fe uptake changed significantly with the treatments. The amount of Fe was the lowest, 410 g ha^{-1} in control while it varied from 540 to 780 g ha^{-1} with the applications. Genotype 9 was the only different one in terms of grain+straw Fe uptake from the others, which were located in the same group.

Nitrogen fertilization did not have considerable effects on Cu, Zn and Mn contents of grain and Cu and Zn contents of straw; it caused significant changes in straw Mn content and grain+straw Cu, Zn and Mn uptakes (Table 6). The interactions to these trace elements were not significant. There were significant differences between genotypes for straw Cu content and grain+straw Cu uptake, both of which were recorded as the highest values in genotype 10. The average grain+straw Cu uptake value of control was 42 g ha^{-1}, as being the lowest, while those of different N treatments were 63, 83, 92 and 97 g ha^{-1}.

The lowest values for grain+straw Zn and Mn uptakes were obtained from the control treatment, 46 and 186 g ha^{-1}, respectively. The highest total Zn uptake (81 g ha^{-1}) was observed in 80 kg ha^{-1}N treatment and total Mn (316 g ha^{-1}) in 120 kg N ha^{-1} treatment.

Grain zinc content was in a range of 14.1 and 17.5 mg kg^{-1} similar to a study conducted by Çakmak *et al.*[25] with triticale and wheat, in which it was found out that grain Zn content varied from 9.7 to 26.6 mg kg^{-1}.

Nitrogen fertilizer increased significantly increased the grain protein yield, grain and straw N contents and straw P and Mn contents and, grain+straw N, P, K, Ca, Mg, Fe, Cu, Zn and Mn uptakes. Eighty kg ha^{-1} of nitrogen fertilizer generally gave the best results when all traits studied were considered.

The differences among genotypes were significant for grain N content, total P, Fe and Cu uptakes and straw

Cu content. The genotype 9 save significantly better total P and Fe uptakes. While genotype 10 save the highest grain N content and total (grain+straw) Cu uptake.

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