Nitrogen Application Management in Triticale under Post-Anthesis Drought Stress

Mokhtar Ghobadi, Mohammad-Eghbal Ghobadi and Sareh-Sadat Sayah

***Abstract*—**Post-anthesis stages of triticale crops are usually exposed to drought stress in semiarid regions. Our objective was to determine the appropriate nitrogen rates in triticale under well-watered and post-anthesis drought stress conditions. In a field experiment, triticale cv. Juanillo-92 were grown under well-watered and post-anthesis water deficit with seven nitrogen fertilizer levels 0, 35, 70, 105, 140, 175 and 210 $kg.ha^{-1}$. The results showed that post-anthesis drought stress decreased significantly biological, grain and straw yields, the number of fertile spikes per m^2, the number of grains per spike and 1000 grain weight. Grain protein content was increased significantly by post-anthesis drought stress, but harvest index was not influenced. Based on the results, the highest grain yield obtained by application 175 and 105 kg $N.ha^{-1}$ under well-watered and post-anthesis drought stress conditions, respectively.

***Keywords*—**Nitrogen managment, post-anthesis drought, triticale.

I. INTRODUCTION

IN semiarid areas of the world with a Mediterranean climate, rainfall decreases and soil evaporation increases in spring when winter cereals such as triticale (*X triticosecale* withmak) enter the grain filling period. Triticale crops often experience water deficit and heat stress during grain growth and development, which limit productivity [1].

Nitrogen is the most important plant nutrient to obtain high triticale yield. The importance of nitrogen fertilizer to increasing of triticale production has been well documented [2]-[6], but still it is difficult to recommend the appropriate rate of nitrogen fertilizer under post-anthesis drought stress conditions. Therefore, the aim of this experiment was to study the effects of nitrogen levels on grain yield, yield components and grain protein content of winter triticale under post-anthesis drought stress and non-stress conditions.

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II. MATERIALS AND METHODS

The present study carried out at college of Agriculture, Razi University, Kermanshah, during 2009-2010. It is located in the west of Iran (34º20' N latitude, 47º20' E longitude, elevation 1351 m above see level) in the moderate-cold and semiarid zone. Field experiment was conducted on a clay soil with pH 7.7, N 0.118%, P_2O_5, K_2O, Mn, Fe, Zn and Cu were equal 10.2, 350, 6.0, 5.6, 1.09 and 2.3 $mg.kg^{-1}$, respectively.

The experiment was as split plot based on RCBD with four replications. Two water treatments namely well-watered and post-anthesis drought stress were as factor-A and seven nitrogen fertilizer levels 0, 35, 70, 105, 140, 175 and 210 $kg.ha^{-1}$ were as factor-B. The source of nitrogen fertilizer was urea. P (50 $kg.ha^{-1}$ as triple superphosphate), K (25 $kg.ha^{-1}$ as potassium sulfate) and one-third of N were applied before planting. Two-third of N were also applied equally at the beginning of stem enlargement (Zadoks Growth Stage (ZGS) = 31) and boot stage (ZGS = 41). Experiment was sown on 6 November 2009. Irrigation was terminated until ear emergence (ZGS = 55) for post-anthesis drought treatment, but for the well-watered treatment irrigation continued until grain dough development stage (ZGS = 85).

The measurements comprised the total above ground dry matter (biological yield), grain yield, straw yield, harvest index, the number of fertile spikes per m^2, the number of grains per spike, 1000 grain weight and grain protein content.

Data were analyzed by ANOVA and means were testes by Duncan's multiple range test using MSTAT-C and SAS statistical analysis packages.

III. RESULTS AND DISCUSSION

Analysis of variance showed that post-anthesis drought stress had significant effect on biological, grain and straw yields, the number of fertile spikes per m^2, the number of grains per spike, 1000 grain weight and grain protein content, but had not on harvest index (table of ANOVA has not shown). Based on the mean comparisons, post-anthesis drought stress decreased biological yield (33.3%), grain yield (36.0%), straw yield (32.1%), the number of fertile spike per m^2 (10.0%), the number of grains per spike (12.8%) and 1000 grain weight (12.6%), but increased grain protein content (19.3%) (Table I).

Increasing of N fertilizer rates increased biological yield under both water treatments, but the highest grain yield under well-watered and post-anthesis drought stress treatments obtained with application of 175 and 105 kg N.ha^{-1}, respectively. Mut *et al.* [6], Djukic *et al.* [3] and Janusauskaite and Lazauskas [4] obtained the highest triticale grain yield with application 180, 240 and 120 kg N.ha^{-1}, respectively.

The number of fertile spikes per m^2, the number of grains per spike and 1000 grain weight increased significantly due to increasing N fertilizer rates up to 210 kg.ha^{-1} under well-watered and up to 105 kg.ha^{-1} under post-anthesis drought stress conditions. Under both water treatments, the grain protein content increased significantly due to more application of N fertilizer.

In addition, to consider economic justification of N fertilizer application, grain production, grain quality and stem lodging, in titicale field 175 kg N.ha^{-1} under well-watered and 105 kg N.ha^{-1} under post-anthesis drought stress conditions are recommended.

TABLE I
MEAN COMPARISONS OF YIELD, YIELD COMPONENTS AND GRAIN PROTEIN

	Biological Yield (kg.ha^{-1})	Grain Yield (kg.ha^{-1})	Straw Yield (kg.ha^{-1})	Harvest Index (%)	Fertile Spikes per m^2	Grains per Spike	1000 Grain Weight (g)	Grain Protein (%)
Non-stress	26824^{a}	7920^{a}	18904^{a}	29.51	494^{a}	52.50^{a}	39.86^{a}	11.35^{b}
Stress	17889^{b}	5064^{b}	12827^{b}	28.39	444^{b}	45.78^{b}	34.82^{b}	13.54^{a}
0 kg N	18064^{d}	4563^{d}	13501^{c}	25.26^{b}	396^{c}	42.91^{c}	33.47^{c}	10.17^{e}
35 kg N	20442^{cd}	5285^{cd}	15156^{abc}	26.65^{b}	438^{b}	45.87^{b}	35.19^{bc}	11.10^{d}
70 kg N	20820^{cd}	6031^{bc}	14788^{bc}	29.57^{ab}	470^{ab}	49.65^{a}	37.37^{ab}	12.10^{c}
105 kg N	22106^{bc}	6922^{ab}	15183^{abc}	31.98^{a}	496^{a}	50.97^{a}	38.45^{a}	12.86^{bc}
140 kg N	24333^{ab}	7203^{a}	17129^{ab}	29.54^{ab}	499^{a}	52.10^{a}	39.10^{a}	13.46^{ab}
175 kg N	25322^{a}	7842^{a}	17480^{ab}	30.29^{ab}	495^{a}	51.38^{a}	39.17^{a}	13.61^{ab}
210 kg N	25410^{a}	7589^{a}	17821^{a}	29.36^{ab}	489^{a}	51.12^{a}	38.66^{a}	13.86^{a}
Non-stress								
0 kg N	21306	5641^{ef}	15664	27.01^{bcd}	404^{ef}	45.38^{de}	36.86^{de}	9.31^{g}
35 kg N	24831	6100de	18730	25.41^{cd}	456^{bcde}	48.60^{cd}	37.86^{bcde}	9.98^{fg}
70 kg N	25120	7056^{cd}	18063	28.35^{abcd}	488^{abc}	52.08^{bc}	39.45^{abcd}	10.27^{efg}
105 kg N	26288	7539^{c}	18749	28.70^{abcd}	505^{ab}	54.25^{ab}	40.68^{abc}	11.43^{de}
140 kg N	29626	8833^{b}	20793	30.00^{abcd}	526^{a}	55.31^{ab}	40.88^{ab}	12.02^{cd}
175 kg N	30235	10368^{a}	19866	34.42^{ab}	541^{a}	55.37^{ab}	41.97^{a}	13.14^{bc}
210 kg N	30364	9901^{ab}	20463	32.65^{abc}	537^{a}	56.55^{a}	41.35^{ab}	13.35^{bc}
Stress								
0 kg N	14822	3484^{g}	11337	23.51^{d}	389^{f}	40.45^{f}	30.08^{g}	11.04^{def}
35 kg N	16053	4469^{fg}	11583	27.88^{abcd}	420^{def}	43.15^{ef}	32.52^{fg}	12.22^{cd}
70 kg N	16520	5006^{ef}	11513	30.80^{abcd}	451^{bcde}	47.22^{d}	35.29^{ef}	13.93^{ab}
105 kg N	17924	6306^{cde}	11618	35.25^{a}	488^{abc}	47.70^{d}	36.22^{de}	14.29^{ab}
140 kg N	19040	5574^{ef}	13465	29.09^{abcd}	472^{bcd}	48.89^{cd}	37.33^{cde}	14.91^{a}
175 kg N	20408	5315^{ef}	15093	26.16^{cd}	449^{cde}	47.40^{d}	36.37^{de}	14.08^{ab}
210 kg N	20457	5277^{ef}	15179	26.07^{cd}	441^{cdef}	45.71^{de}	35.96^{de}	14.37^{ab}
% CV	12.05	13.74	16.13	15.85	7.20	5.21	5.91	7.09

Mean followed by the same letter(s) in each column (between two horizontal lines) are not significantly different (Duncan 5%)

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