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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 7 (3): 353-358, 2004
ISSN 1028-8880

Efficiency of Different Top dressed Nitrogen on Triticale (X *Triticosecale* Wittmark) under Contrasting Precipitation Conditions in Semiarid Region

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Abstract: In order to evaluate the influence of different Top dressed nitrogen (N) rates (0, 40 and 70 kg ha^{-1}) and N fertilizers (ammonium sulphate, calcium ammonium nitrate and urea) on grain yield, number of kernels per spike, spike weight, number of spike per m^2, test weight, harvest index and protein content in a triticale (cv. Tatlıcak 97) variety adapted to semiarid conditions. Field studies were conducted in 2000-2001 and 2001-2002 growing seasons. Normally, in growing season (October-June) average precipitation rate in Central Anatolian Region is approximately 338.3 mm per year. However total precipitation rates during the growing seasons of the experiments were quite unusual. In the second year, total precipitation was extremely higher (403.8 mm) than that in the first year (212.5 mm). In the first year, despite harvest index was significantly affected by fertilizer kind and "fertilizer x rate" interaction, the number of head per sqare meter and crude protein rate were affected significantly only by nitrogen rates. None of the characters under investigation were affected significantly by fertilizer kind or "fertilizer x rate" interaction in the second year.

Key words: Drought stress, nitrogen fertilizer, triticale, yield components

INTRODUCTION

Drought stress is an important problem affecting the yield in all crops. Cereal growth under rainfed conditions with erratic rainfall is strongly depended upon water available in the rhizosphere for taking up essential minerals from soil[1]. Water requirements of cereals vary during the growing stages. While an intensive drought mainly affects the number of kernels per unit area, a mild drought may cause a decrease in grain weight[2]. Reductions in the number of spikes per square meter and the number of kernel per spike in cereals have been reported to be related with pre-anthesis water stress[3]. Water deficit during the anthesis may lead to a loss in yield by reducing spike number and spikelet fertility[4,5]. Drought stress during the grain filling period if accompanied by high temperature, accelerates leaf senescence and shortens the duration of grain filling and decreases grain weight[6,7] by reducing translocation of assimilates to the developing kernels[8].

Compared to other mineral nutrients, N is required in relatively high quantities by cereals for optimum vegetative and reproductive growth. In the absence of drought stress, applied N normally increase stem carbohydrate and dry weight accumulation[9]. If cereal crops are subjected to intense post-anthesis drought stress, grain ripening[10] and protein formation[11] are mainly dependent on the contribution of vegetative reserves[12], including leaf[13], stem[8] and other tillers[14-16].

The numerous studies were done by using triticale. However, little research has been reported on effect of N fertilizers and rates on yield and yield components of triticale. The main objective of the present study was to determine the influence of different Top dressed N rates and N fertilizers on yield and yield components of triticale (cv. Tatlıcak 97) grown in semiarid lands of the Central Anatolian Plateau.

MATERIALS AND METHODS

An experiment was conducted by using a winter triticale (cv. Tatlıcak 97) during the growing seasons of 2000-2001 and 2001-2002 at Eskisehir Province of the semiarid Central Anatolian Region of Turkey. The amount and distribution of precipitation are important factors determining the yields of cereals grown in the region. Eskisehir is located at 39°48' N, 30°31' E at an elevation of 789 m above the sea level.

The field was sown after 14 months of fallow. A factorial randomized complete block design with four replications was used in the experiment. Triticale planted with 210 kg ha^{-1} seed rate, 23.4 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1} applied as di-ammonium phosphate in the sowing. The sowing was done in October (6th in 2000 and

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10th in 2001). Each plots (10 m^2) were six rows and the space between the rows was 17.5 cm. At tillering stage, the plots were Top dressed by completing to total of 40 kg N ha^{-1} or 70 kg N ha^{-1} as ammonium sulphate (AS), calcium ammonium nitrate (CAN) or urea. The plants were harvested in July (2nd in 2001 and 17th in 2002).

Some of the properties of soils where experiments were conducted in two years were relatively similar, all being shallow (30-35 cm) with low water-holding capacity, moderately lime and pH 8.2. The soil of the experiment site in the first year was sandy loam, while in the second year was sandy. As in most soils in Central Anatolia, soils of the experiment sites were poor in organic matter, thus low in N supply to plants.

The Central Anatolia has annual precipitation varying between 250 and 450 mm. The two years of the field experiment had contrasting precipitation regime (Fig. 1).

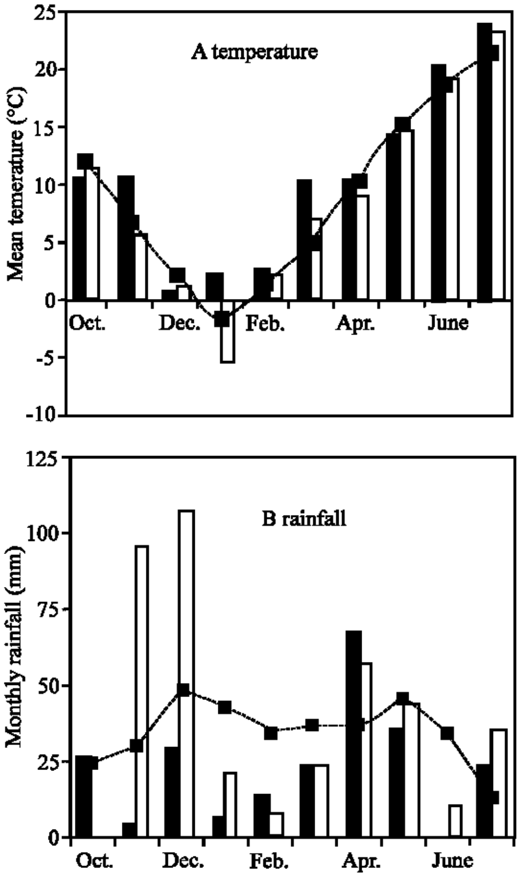

Fig. 1: Monthly temperature (A) and rainfall (B) in the drought year (shaded bars: 2000-2001), the rainy year (unshaded bars: 2001-2002) and long term (■: 1940-2000)

The precipitation of the growing season in the first year was 212.5 mm which was insufficient for plants need and less than long term average, with a very dry period from the sowing to the tillering stage. However, in the second year, total precipitation was realized as 403.8 mm which was quite higher than the average of the region.

The precipitation rates and total temperature regarding the Growing Stages (GS) were shown in the Table 1. Severe drought occurred from the heading to the maturity stage in the first year (Table 1), because the rainfall during this stage was almost absent, while this stage in the second year was excessively rainy which has 40% of annual precipitation.

The number of grain per spike, spike weight and thousand grain weight were determined on randomly selected twenty-five plants from the each plot. Harvest index, the number of spike per square meter, grain yield (kg ha^{-1} at 11% moisture) and test weight (kg hl^{-1}) were also determined for the each plot. Kjeldahl digestion method was used for the analysis of grain protein. Reduction in the grain yield and yield components due to drought stress in 2000-2001 growing year in comparison to 2001-2002 growing year was calculated as in Royo and Blanco[6].

$$\%\text{reduction} = 100 \times \frac{(R-D)}{D}$$

where R and D are the values of variables in the rainy year (2002) and the drought year (2001), respectively. The reduction was calculated individually for each N fertilizer and N rate.

Standard analyses of variance were used to analyse the data obtained. Means were tested by the LSD multiple range test at $P = 0.05$.

RESULTS

The effects of different N levels and N-fertilizers on yield and yield components of triticale under the drought stress and the rainy year are shown in Table 2 and 3, respectively. The values of the yield and yield components in the drought year were lower than those of the rainy year.

In the first year under drought stress, number of spikes per m^2 ($P < 0.05$) and protein ($P < 0.1$) were affected by N levels. It was found that number of spikes per m^2 was the highest at control plots (no Top dressed N fertilizer) and protein was the highest at 70 kg N ha^{-1} in the drought year (Table 2).

In the rainy year, the number of kernels per spike ($P<0.01$), the spike weight ($P < 0.01$), the number of spikes m^{-2} ($P < 0.01$), the harvest index ($P < 0.05$) and the grain yield ($P < 0.1$) were significantly affected by N levels (Table 3).

Table 1: Mean duration of triticale development phases (GS) in the years of 2001 and 2002 growing seasons

	2000-2001				2001-2002			
Developmental phase	Dates †	Day ‡	R (mm)	T (°C)	Dates †	Day ‡	R (mm)	T (°C)
GS1: Sowing to tillering	06.10.2000	159	90.8	735.7	10.10.2001	147	235.5	549.4
	14.03.2001	(61%)	(43.0%)	(4.6)$^{\phi}$	05.03.2002	(54%)	(58.0%)	(3.7)$^{\phi}$
GS2: Tillering to heading	15.03.2001	65	120.9	721.2	06.03.2002	77	118.2	744.5
	18.05.2001	(25%)	(57.0%)	(11.1)	21.05.2002	(28%)	(29.0%)	(9.7)
GS3: Heading to anthesis	19.05.2001	5	0	84.8	22.05.2002	4	1.8	82.6
	23.05.2001	(2%)		(16.9)	26.05.2002	(2%)	(0.5%)	(20.7)
GS4: Anthesis to maturity	24.05.2001	35	0.8	680.9	27.05.2002	47	48.3	924.8
	27.06.2001	(13%)	(0.4%)	(19.5)	12.04.2002	(17%)	(12.0%)	(19.7)
GS1+GS2+GS3+GS4		264	212.5	2223.0		275	403.8	2301.0

R = Total rainfall; T = Total temperature; † = mean of plots ; ‡= given in parenthesis is percentage of period ; ϕ = mean of daily temperature

Table 2: Means yield and yield components under dry year (2001)

Treatment	Grain yield (kg ha^{-1})	Number of kernel per spike	Spike weight (g)	1000-grain weight (g)	Number of spikes (m^{-2})	Test weight (kg hl^{-1})	Harvest index (%)	Protein (%)
Nitrogen level (N) (kg/ha)								
0	714.7	29.2	0.79	24.80	543.5	73.30	22.70	12.90
40	736.5	29.3	0.73	24.40	464.2	72.50	20.40	13.50
70	713.9	29.8	0.74	24.20	518.3	71.50	19.90	14.00
LSD (0.05)	14.9	2.9	0.12	1.53	57.2	1.77	3.03	0.89
N (P-value)	NS	NS	NS	NS	*	NS	NS	+
N fertilizer (F)								
AS	763.4	30.0	0.81	24.80	488.8	72.90	22.60	13.50
CAN	719.6	29.2	0.76	24.30	515.3	72.50	21.20	13.30
Urea	682.0	29.0	0.69	24.30	521.9	71.60	19.10	13.70
LSD (0.05)	14.9	2.9	0.12	1.53	57.2	1.77	3.03	0.89
F (P-value)	NS	NS	NS	NS	NS	NS	+	NS
NxF (P-value)	NS	NS	NS	NS	NS	NS	*	NS

Note: AS = Ammonium sulphate; CAN = calcium ammonium nitrate; NS = Non-significant; + = Significant at $P < 0.10$; * = Significant at $P < 0.05$

Table 3: Means yield and yield components under rainy year (2002)

Treatment	Grain yield (kg ha^{-1})	Number of kernel per spike	Spike weight (g)	1000-grain weight (g)	Number of spikes (m^{-2})	Test weight (kg hl^{-1})	Harvest index (%)	Protein (%)
Nitrogen level (N) (kg ha^{-1})								
0	5235.3	62.9	3.04	47.30	631.3	76.60	31.30	11.60
40	5503.3	58.8	2.72	47.30	568.3	76.80	28.90	11.60
70	5885.0	57.4	2.59	46.90	582.6	76.90	29.20	11.60
LSD (0.05)	56.1	3.5	0.19	1.24	38.5	0.84	1.81	0.21
N (P-value)	+	**	**	NS	**	NS	*	NS
N fertilizer (F)								
AS	5659.6	60.6	2.83	47.60	599.1	76.60	30.30	11.60
CAN	5636.2	59.8	2.81	47.00	582.5	77.00	29.30	11.70
Urea	5327.8	58.6	2.71	46.80	600.5	76.50	29.80	11.70
LSD (0.05)	56.1	3.5	0.19	1.24	38.5	0.84	1.81	0.21
F (P-value)	NS	NS	NS	NS	NS	NS	NS	NS
N x F (P-value)	NS	NS	NS	NS	NS	NS	NS	NS

Note: AS = Ammonium sulphate; CAN = calcium ammonium nitrate; NS = Non-significant; + = Significant at $P < 0.10$; * = Significant at $P < 0.05$; ** = Significant at $P < 0.01$

Table 4: Effect of drought (% reduction) on yield and yield components

Nitrogen fertilizer	Rates (kg ha^{-1})	Grain yield	Number of kernel per spike	Spike weight	1000-grain weight	Number of spikes (m^{-2})	Test weight	Harvest Index	Protein*
0		86	53	74	47	14	4	27	9
AS	40	87	52	73	50	26	6	32	16
	70	85	45	66	47	14	5	18	15
CAN	40	86	49	72	49	2	6	23	12
	70	89	51	73	48	16	8	31	14
Urea	40	85	49	74	46	23	5	32	12
	70	89	48	75	50	3	9	48	21

*Drought increased the protein content

The highest value of the number of kernels per spike, spike weight, number of spikes per m^2 and harvest index under rainy conditions was found at control plots. When N levels were increased, grain yields increased in the rainy year. Thousand kernel weight and test weight were not affected by N levels in both years.

Nitrogen fertilizers and "nitrogen levels x nitrogen fertilizer" interaction did not affect yield and yield components except only harvest index in the drought year. Also, these factors were not effective on any yield and yield components in the rainy year (Table 3).

The drought stress reduced the grain yield and the yield components to a similar extent for three kinds of N fertilizer and N rates used in the trials, except for the protein rate (Table 4). As expected, the greatest effect of the drought stress was found on the grain yield. The protein content was not affected negatively by the drought stress. In contrast, grain protein rate was increased (mean 14 %) under the drought stress.

The reduction in the yield components due to the drought stress was in following order: The grain yield (mean 87%), the spike weight (72%), the number of kernels per spike (50%), 1000 grain weight (48%), the harvest index (30%), the number of spikes m^{-2} (14%) and the test weight (6%).

DISCUSSION

The aim of the present study was to evaluate the influence of different N sources and rates on the yield and yield components of triticale grown under semiarid conditions. It is known that triticale is more resistant to extreme weather conditions (cold and drought stress) than wheat[17]. Tatlıcak 97 is a variety which adapted to semiarid conditions of the Central Anatolian Region of Turkey. The soils of Central Anatolian Region are low in fertility because of erosion and mono-culture agriculture. Moreover, climatic changes in the last two decades affected substantially yields of cereals.

The drought stress is generally effectual from end of May to the middle of September in Central Anatolia Region. Thus, the soil profile has not mostly enough water during the sowing time of cereals in this region. In the first year, precipitation during the experiment was totally 90.8 mm which was 43% of the total rainfall from the sowing to the tillering stage. This rate was 53.5% of total rainfall for the same period of the second year. In the second year of the experiment, total temperature was lower and growing period was longer than in the first year. Because of less rainfall, water deficit occurred in soil in the first year. Therefore, the drought stress affected significantly the yield and the yield components of triticale in this year with low rainfall. Emergence of plants in the first year was late because of soil dryness. Late emergence of plants affected tillering stage; hence, tillers were few and weak. The duration of GS 1 in the second year (rainy-147 days) became shorter than that in the second year (dry year-159 days). Number of tillers was higher and plants were more vigorous in the second year compared to the first year.

Nitrogen fertilizers were applied at the beginning of the GS 2 which corresponds to the starting of tillering. At this stage, the precipitation in the first year was about the same as of the second year. Thus, Top dressed N fertilizers might be efficiently used equally by plants in each two years. The plants in the drought year were weak and thin because of water deficit at the GS 1. But the water taken up by plants at GS 2 was adequate for the formation of tillering and heading. Although the plants in the GS 2 in the drought year and rainy year were subjected to nearly the same amount of total temperature range, the mean daily temperature in the second year (9.7°C) was lower than in the first year (11.1°C). According to Rickman and Klepper[18], phenological events such as tillering, jointing and terminal spikelet are related to the yield components. If plants were stressed by lack of water and high temperature from tillering to heading stage, heads per plant and kernels per head would be affected. Day and Intalap[4] explained when wheat was stressed at jointing stage, reduced grain yield resulted in fewer heads per unit area and fewer seeds per head. Beside drought, temperature is also effective on growth stage. It has been reported that at the end of the tillering or beginning of the grain filling, if the temperature rises 1°C, it was associated with a 4% reduction in grain yield[19]. This was attributed to the effect of the temperature on grains m^{-2} via changes in spike m^{-2} and grain/spikelet. In our experiment, the water deficit and high temperature decreased the yield and yield components of triticale in the first year (Table 4).

At the GS 3 in drought year, high temperature and low precipitation occurred. This stage transited fast to the grain filling stage within a short time due to the water stress. Lacking of the available water within the rhizosphere should cause low nutrient uptake by plants. The drought stress at anthesis causes low grain yield[20,21].

The GS 4 was at the anthesis to maturity. The GS 4 in drought year was shorter (35 days) than that of rainy year (47 days). While the plants were GS 4 there was not any rainfall in the first year while the plants at the GS 4 in the second year were subjected to 12% of total precipitation falled on crops. According to Kobata *et al.*[10] at the GS 4 during the first 19 days after anthesis, grain yield was reduced by 33% at low humidity mainly due to reduction in grain size. Meanwhile, at this stage protein develops in the grain. It is known that protein content is affected by amount of the precipitation and temperature during maturity. As shown by many studies[5,11] when the precipitation is relatively low and temperature is high, protein content increases. Also, in this study protein content (mean 13.5%) under the drought year was higher than in the rainy year (11.6%).

In this study, results showed that N-sources did not affected differentially the yield of triticale under drought condition. It is important to compare the difference of drought and high rainfall effects on yield components. Our data demonstrated that N-sources and N rates, under erratic and insufficient precipitation, have no effect on increases in grain yield. Environmental conditions during the growing season can have a significant effect on the yield response of winter triticale to N fertilization, as indicated for winter wheat[22,23] drought stress reduced the yield of triticale. Our results indicated that the nitrogen fertilizers had no effect on the yield and yield components of triticale under drought and rainy conditions.

According to our results, urea application increased the protein content in grain of triticale. As expected, the protein content decreased in the second year which was rainy. Increase in protein content was found to be correlated by increases in N rate as indicated by Hunter and Stanford[24] and Altenbach *et al.*[16]. Also, as our results shown, in other studies increased N rates resulted in higher grain yields in triticale[25,26].

It can be concluded that differences in the grain yields and the values of the yield components of triticale between two years resulted from the different rates of water taken up by plants during the growth stage of the plants. While the grain yield was not affected differentially by N fertilizers, it was increased by increasing of applied N rate. But, the usefulness of the increased N rates to triticale is only possible when the plants take up enough water during the critical growth stage. It can be suggested that more studies about increased N rates in triticale should be maintained for not extreme but for an average year of semiarid regions with any N- source. However, urea form is much more preferable to increase protein content in grain of triticale.

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