Pak. J. Agri. Sci., Vol. 49(4), 491-496; 2012
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
http://www.pakjas.com.pk

OPTIMIZING RATE OF NITROGEN APPLICATION FOR HIGHER GROWTH AND YIELD OF WHEAT (*Triticum aestivum* L.) CULTIVARS

Muhammad Maqsood, Muhammad Asif Shehzad*, Amir Asim and Wahid Ahmad

Department of Agronomy, University of Agriculture, Faisalabad-38040, Pakistan
***Corresponding author's email: asifbukhari01@gmail.com**

In order to optimize the nitrogen rates in three wheat (*Triticum aestivum* L.) cultivars for obtaining higher grain yield, a split plot experiment based on Randomized Complete Block Design with three replicates was conducted in the research field of University of Agriculture, Faisalabad during Rabi season 2006-07. Among treatments nitrogen levels (N_0= 0, N_1= 50, N_2= 100, N_3= 150 kg ha^{-1}) in main while wheat cultivars (V_1= Punjnad-I, V_2= Fareed-2006, V_3=Uqab-2000) were allocated in sub plots during the course of growing season. Traits as plant height, fertile tillers, spike length, spikelets $spike^{-1}$, grains $spike^{-1}$, 1000-grain weight, straw yield, grain yield and harvest index (HI) were significantly (P=0.05) affected by treatment combinations. Maximum grain yield was obtained by V_3 (Uqab-2000) cultivar when treated with N_3 (150 kg ha^{-1}) fertilizer level. Also, results showed that with increasing nitrogen rates, wheat yield increases significantly up to a level of significance (P=0.05). Increasing nitrogen levels led to significantly increase in plant height (101.81cm), spike bearing tillers (495.77), grains $spike^{-1}$ (61.45), straw yield (8.60 t ha^{-1}) and harvest index (36.17%) of V_3 (Uqab-2000). In all traits except germination count, V_3 (Uqab-2000) was found to be superior.
Keywords: Wheat cultivars, nitrogen rate, grain yield, growth, Uqab-2000, *Triticum aestivum* L.

INTRODUCTION

Wheat (*Triticum aestivum* L.), being a major food crop of Pakistan, occupies a central position in forming agricultural policies and dominates agronomic crops in terms of acreage and production (Shehzad *et al.*, 2012a; Shehzad *et al.*, 2012b). Currently, it is cultivated on an area of 8.66 million hectares with an average yield of 2714 kg ha^{-1} which is 4.2% less over last year. The wheat crop is, however provisionally estimated at 23.52 million tons highest wheat production in the country's history (GOP, 2012).

Nitrogen occupies a conspicuous place in plant metabolism. All vital processes in plant are associated with protein, of which nitrogen is an essential constituent. Consequently to get more crop production, nitrogen application is essential in the form of chemical fertilizer. Proper use of nitrogen is also considered for farm profitability and environment protection. Among all the essential nutrients applied in the field, nitrogen is the most important for vegetative crop growth, plant productivity and grain quality (Gwal *et al.*, 1999; Ali *et al.*, 2000; Iqbal *et al.*, 2012).

Nitrogen being an integral part of structural and functional proteins, chlorophyll and nucleic acid affects plant growth and development pattern by changing canopy size and structure (Tisdale *et al.*, 1990; Sinclair, 1990; Muchow and Sinclair, 1994) and is required throughout the crop growth period from vegetative stage to subsequent harvesting (Rafiq *et al.*, 2010; Ali, 2011). The most pressing target of improving agricultural nitrogen use efficiency is to improve the recovery of N from fertilizer (Dawson *et al.*, 2008) and globally, only a third of the N in fertilizer applied to cereal crops is harvested in the grain (Raun and Johnson, 1999). Plant nitrogen accumulation, as a product of plant nitrogen content and plant mass, strongly affects yield and quality formation in crop production (Guo *et al.*, 2005). Addition of NPK fertilizers improves crop yields (Shehu *et al*. 2010). Since nitrogen supply at the right time and appropriate amount, is necessary to evaluate tissue nitrogen status and recommend nitrogen dressing plan from indicative nitrogen content and nitrogen accumulation in crop plants. High nitrogen fertility levels increases leaf area indices but the great difference during maturation is the ability to maintain a larger number of green leaves late in the season as compared to low nitrogen fertility levels (Frink *et al.*, 1999). Uptake efficiency and utilization of nitrogen in the production of grains requires the processes of uptake, translocation, assimilation and redistribution of nitrogen operate nitrogen use efficiency effectively that varies considerably depending upon the native soil nitrogen, developmental stage of the plant and yield potential. Optimizing nitrogen use, achieving acceptable grain yield and maintain adequate grain protein require the knowledge of expected nitrogen uptake efficiency and utilization within the plant in relation to the rate and timing of nitrogen applied (Wuest and Cassman, 1992). In view the importance of nitrogen nutrition for wheat crop production, the present study was therefore planned to determine the optimum level for nitrogen requirement and its effect on growth and yield of three wheat cultivars under semi arid environment.

MATERIALS AND METHODS

The proposed study was conducted at the Agronomic Research Area, University of Agriculture, Faisalabad, to evaluate the effect of different nitrogen rates on growth and yield of wheat cultivars during Rabi season 2006-07. The experiment was planned in randomized complete block design (RCBD) with split plot arrangement having a net plot size of 5m × 1m in triplicate run. Prior to sowing, soil samples were taken to a depth of 30cm for physiochemical analysis which showed a soil pH of 8.1, soil organic matter of 0.81%, EC of 1.18 dSm^{-1}, available phosphorus of 13.3 ppm, available potassium of 170 ppm and saturation percentage of 38. Wheat cultivars (Punjnad-I, Fareed-2006 and Uqab-2000) were sown during 1^{st} week of December 2006 on a well-prepared seedbed in 25 cm apart rows with the help of a single row hand drill with a seed rate of 125 kg ha^{-1}. Fertilizers, urea was used as a source of nitrogen, single super phosphate as a source of phosphorus and sulphate of potash as a source of potassium. All P, K and ½ N was side dressed at the time of sowing and remaining ½ N was top dressed at the time of first irrigation. Phosphorus and potash was used at the rate of 100 kg ha^{-1} and 62 kg ha^{-1}, respectively. Nitrogen levels (N_0= 0, N_1= 50, N_2= 100, N_3= 150 kg ha^{-1}) and wheat cultivars (V_1= Punjnad-I, V_2= Fareed-2006, V_3=Uqab-2000) were allocated in main and sub plots respectively. All other cultural practices were kept normal and uniform for all experimental treatments. Observations regarding germination count (m^{-2}), plant height (cm), fertile tillers, spike length (cm), spikelets $spike^{-1}$, grains $spike^{-1}$, 1000-grain weight (g), straw yield (t ha^{-1}), grain yield (t ha^{-1}) and harvest index (%) were recorded using standard procedures during the course of study.

Data collected were analyzed statistically using Fisher's analysis of variance (ANOVA) technique. Differences among the treatment's means were compared by using Duncan's New Multiple Range (DMR) test at 5% probability level (Steel *et al.,* 1997).

RESULTS AND DISCUSSION

Germination count (m^{-2}): Optimum and uniform germination of wheat plants plays an important role in good crop stand which is ultimately responsible for higher grain yield. Data pertaining to germination count per unit area of three wheat cultivars as affected by different levels of nitrogenous fertilizer given in Table 1; 2. Statistical results about germination count (m^{-2}) indicated that the differences among the varieties and varying fertilizer levels of nitrogen could not reach a level of significance ($P\leq0.05$). Similarly, the interaction between the two factors was also recorded to be non significant. Non-significant effects of varieties on germination count are against finding of Li *et al.* (2007) who reported that germination seems to be controlled by uniform use of seed rate, seed bed preparation and soil type.

Plant height (cm): Statistical analysis of the data along with the statistical summary of the results showed that plant height was significantly affected by different varieties as well as by different nitrogen rates. The interaction between two factors (nitrogen and cultivars), however, could not reach the level of significance ($P\leq0.05$). As regards the nitrogenous fertilizer levels, the plant height in all the treated plots was significantly higher compared to control. Non-significant differences were found among N_1 (50 kg ha^{-1}), N_2 (100 kg ha^{-1}) and N_3 (150 kg ha^{-1}) treatments, which on an average produced plants of (100.32 cm) height parallel to control (91.19 cm). Out of three varieties V_3 (Uqab-2000) produced the tallest plants (104.13 cm), but V_1 (Fareed-06) and V_2 (Punjnad-I) were statistically at par with each other. The variety V_2 (Punjnad-I) produced plants of the lowest height (94.97 cm) (Table 1; 2). The results indicated that varieties differed in plant height, which may be attributable to differences in their genetic makeup. Increase in plant height in the nitrogen added plots might be due to increase in vegetative growth of the plants (Saren and Jana, 2001; Hameed *et al.,* 2003; Shehzad *et al.,* 2012c. Similarly the difference in plant height was due to differences in varieties were reported by Ashour and Haleem, (1995).

Spike bearing tillers (m^{-2}): Data pertaining to spike bearing tillers (m^{-2}) showed that the individual effect of different nitrogenous fertilizer levels and varieties was found to be significant but its interactive study did not reach the level of significance (Table 1; 2) ($P\leq0.05$). The number of spike bearing tillers was the highest (495.77) in case of N_3 (150 kg N ha^{-1}) nitrogenous fertilizer level compared to lowest number of spike bearing tillers (317.88) in case of N_0 (control) treatment. The number of spike bearing tillers increases with increasing nitrogen level. Statistical results revealed that variety V_3 (Uqab-2000) produced significantly the higher number of spike bearing tillers (420.83) parallel to V_2 (Fareed-2006) which produced the lowest tillers (403.66) as spike bearing tillers in V_1 (Punjand-I) and V_2 (Fareed-2006) were statistically at par with each other. The number of fertilized tillers was reduced in all varieties at zero fertilizer level. These results are in agreement with those of obtained by Naeem (2001) and Islam *et al.* (2002).

Spike length (cm): The length of spike also determines the productivity of wheat crop, which ultimately contribute to final grain yield. The analysis of variance showed that all varieties differed significantly from one another while the nitrogenous fertilizer levels and their interaction with the varieties was not reach the level of significance ($P\leq0.05$). The highest spike length (16.46 cm) was recorded in Uqab-2000 (V_3) parallel to the lowest length (13.85 cm) which was obtained from Punjnad-I (V_1) while V_2 (Fareed-2006)

Table 1. The mean squares of nitrogen treatments on yield and yield components of wheat (*Triticum aestivum* L.) cultivars

SOV	df	Mean square									
		Germination count (m^{-2})	Plant height (cm)	Spike bearing tillers	Spike length (cm)	Spikelets $spike^{-1}$	Grains $spike^{-1}$	1000- grain weight (g)	Straw yield ($t\ ha^{-1}$)	Grain yield ($t\ ha^{-1}$)	Harvest index (%)
Replication (r)	2	14929.53	30.42	37.19	0.41	0.41	10.80	10.27	0.027	0.003	0.39
Nitrogen (N)	3	3067.90^{NS}	222.25^{**}	64207.00^{**}	1.25^{NS}	1.25^{NS}	22.41^{*}	22.61^{NS}	13.81^{**}	6.40^{**}	33.09^{**}
Error a	6	839.15	6.96	110.30	0.38	0.38	1.42	5.66	0.086	0.026	0.87
Varieties (V)	2	1552.37^{NS}	320.45^{**}	945.44^{**}	20.66^{**}	20.66^{**}	826.39^{**}	123.74^{**}	5.63^{**}	3.05^{**}	28.73^{**}
N × V	6	466.86^{NS}	28.85^{NS}	115.67^{NS}	0.12^{NS}	0.12^{NS}	21.37^{NS}	5.24^{NS}	0.56^{**}	0.35^{**}	9.94^{**}
Error b	16	572.71	25.89	95.48	0.17	0.17	34.22	3.27	0.027	0.02	1.23

^{NS} *Non-significant;* ** *Indicates the significance at 5% level of probability*

Table 2. Growth and yield response of different wheat (*Triticum aestivum* L.) cultivars as affected by different nitrogen rates

Treatments	Germination count (m^{-2})	Plant height (cm)	Spike bearing tillers	Spike length (cm)	Spikelets $spike^{-1}$	Grains $spike^{-1}$	1000-grain weight (g)	Straw yield ($t\ ha^{-1}$)	Grain yield ($t\ ha^{-1}$)	Harvest index (%)
Nitrogen (N)										
N_0	329.11	91.19 b	317.88 d	14.76	13.73	45.19 b	38.48	5.93 c	2.75 c	31.53 b
N_1	340.55	101.23 a	362.55 c	14.85	14.81	60.48 a	38.36	7.33 b	3.84 b	32.45 b
N_2	353.55	97.94 a	467.55 b	15.58	16.14	60.52 a	40.96	8.46 a	4.47 a	35.13 a
N_3	348.88	101.81 a	495.77 a	15.18	15.37	61.45 a	41.36	8.60 a	4.59 a	36.17 a
LSD (*P*=0.05)	NS	4.75	12.11	NS	NS	5.46	NS	0.34	0.18	1.04
Varieties (V)										
V_1	338.16	95.03 b	408.33 b	13.85 c	13.87 c	57.14 a	36.17 b	7.70 b	3.53 c	33.70 a
V_2	326.33	94.97 b	403.66 b	14.98 b	14.93 b	55.14 b	40.88 a	6.84 c	3.72 b	33.21 b
V_3	364.58	104.13 a	420.83 a	16.46 a	16.49 a	58.46 a	42.30 a	8.20 a	4.49 a	34.55 a
LSD (*P*=0.05)	NS	3.66	8.46	0.36	0.37	1.65	1.56	0.14	0.13	1.29
Interaction (N × V)										
$N_0 \times V_1$	322.00	86.43	320.33	13.40	13.40	45.23	34.30	5.86 h	2.70 f	31.52 d
$N_0 \times V_2$	303.33	87.33	312.00	14.90	14.90	44.10	40.36	5.73 h	2.66 f	31.40 d
$N_0 \times V_3$	362.01	99.83	321.33	16.00	16.00	46.26	40.80	6.21 g	2.90 f	31.68 d
$N_1 \times V_1$	334.66	101.63	365.66	13.80	13.80	57.66	33.40	7.06 e	3.23 e	31.32 d
$N_1 \times V_2$	321.02	98.43	349.30	14.53	14.53	61.10	40.13	6.63 f	3.46 e	31.74 d
$N_1 \times V_3$	366.00	103.63	372.66	16.23	16.23	62.70	41.56	8.30 c	4.83 bc	34.31 c
$N_2 \times V_1$	362.66	93.53	459.00	14.30	14.30	64.10	37.60	8.76 b	4.06 d	35.19 bc
$N_2 \times V_2$	340.02	93.23	461.66	15.56	15.56	57.73	42.43	7.60 d	4.13 d	38.41 a
$N_2 \times V_3$	358.01	107.06	482.00	16.90	16.90	59.73	42.80	9.03 ab	5.23 a	31.81 d
$N_3 \times V_1$	333.33	98.53	488.33	13.90	13.90	61.57	39.40	9.13 a	4.16 d	36.80 ab
$N_3 \times V_2$	341.03	100.90	491.66	14.93	14.93	57.63	40.63	7.43 d	4.63 c	36.68 ab
$N_3 \times V_3$	372.33	106.00	507.33	16.73	16.73	65.16	44.06	9.26 a	5.00 ab	35.05 bc
LSD (*P*=0.05)	NS	NS	NS	NS	NS	NS	NS	0.29	0.27	1.79

^{NS} *Non-significant; Any two means sharing same letters did not differ significantly at 5% level of probability* produced the spike length of (14.98 cm) (Table 1; 2). The increase in spike length may be due to proper application of nitrogen fertilizer as nitrogen fertilizer increased vegetative growth efficiently. These results are in line with Gwal *et al.* (1999) and Ali *et al.* (2000).

***Spikelets spike^{-1}*:** Statistical comparison of treatments showed that number of spikelets spike^{-1} of three wheat varieties that treated with different levels of nitrogen fertilizer was found to be significant ($P \leq 0.05$), while the single effect of nitrogen fertilizer levels as well as interaction between these two factors did not reach a level of significance (Table 1; 2). The maximum number (16.49) was recorded in case of V_3 (Uqab-2000) but it differed significantly from other two varieties, V_2 (Fareed-2006) and V_1 (Punjnad-I), respectively. The maximum number of spikelets spike^{-1} in V_3 (Uqab-2000) may be attributed to its higher genetic potential for production of spikelets spike^{-1} than that of V_2 (Fareed-2006) and V_1 (Punjnad-I). The ineffectiveness of all the nitrogenous fertilizer levels shows that formation of spikelets spike^{-1} is not affected by environmental factors and this trait is controlled by genetic makeup of the variety. These results are in conformity with those of obtained by Islam *et al.* (2002).

***Grains spike^{-1}*:** Number of grain spike^{-1} stands an important yield contributing parameter. It is clear from the data that the differences among three varieties for number of grains spike^{-1} were significant at ($P \leq 0.05$) while grains found spike^{-1} were statistically significant in nitrogenous fertilizer treatments at 1% level and the interaction between these two factors could not reach a level of significance. The maximum number of grains spike^{-1} (61.45) were recorded in N_3 (150 kg N ha^{-1}) compared to lowest number of grains (45.19) that was noted in case of N_0. The statistical results for grains spike^{-1} remained at par in case of N_1, N_2 and N_3 treatments. In case of individual effect of varieties the maximum grains spike^{-1} were attained by V_3 (Uqab-2000) (58.46) as compared to V_1 (Punjnad-I) (55.14) (Table 1; 2). These results are in conformity with those of Khaliq *et al.* (1999), Maqsood *et al.* (2002) and Sabir *et al.* (2002).

1000-grain weight (g): Statistically analyzed data on 1000-grain weight revealed that the differences in 1000-grain weight due to the varieties were highly significant while the effect of different nitrogen levels and the interaction between the varieties and nitrogenous fertilizer levels were non-significant ($P \leq 0.05$) (Table 1; 2). 1000-grain weight was the highest (42.30 g) observed in V_3 (Uqab-2000) which was statistically at par with V_2 (Fareed-2006) that produced the 1000-grain weight of (40.88 g) but it differed significantly from V_1 (Punjnad-I) that produced the lowest 1000-grain weight of (36.17 g). The differences in 1000-grain weight among the wheat varieties may be attributed to their variable inherent potential for this trait. These results are in line with those of obtained by Basit, (1996).

***Straw yield (t ha^{-1})*:**

Statistical analysis of the results described that among nitrogen levels, the highest value for straw yield (8.60 t ha^{-1}) was obtained by N_3 (150 kg N ha^{-1}) treatment which was statistically at par with treatment N_2 (100 kg N ha^{-1}) that produced (8.46 t ha^{-1}) of straw yield. This value significantly differed than the straw yield of treatment N_1 (50 kg N ha^{-1}) and N_0 (control) that produced (7.33 t ha^{-1}) and (5.93 t ha^{-1}) of straw yield, respectively as the increase in straw yield was recorded with the increasing nitrogenous fertilize levels from 0 to 150 kg ha^{-1}. The maximum straw yield (8.20 t ha^{-1}) was obtained in case of V_3 (Uqab-2000) but it differed significantly from V_1 (Punjnad-I), which on an average produced (7.70 t ha^{-1}) of straw yield. The entries showed that the interaction of different nitrogenous fertilizer doses with varieties significantly affected the straw yield ($P \leq 0.05$). The straw yield was the highest (9.26 t ha^{-1}) in treatment $N_3 \times V_3$, which was statistically at par with $N_3 \times V_1$ and $N_2 \times V_3$. The treatment $N_2 \times V_1$ produced (8.76 t ha^{-1}) straw yield differed significantly from $N_3 \times V_3$ but the lowest value of straw yield (5.73 t ha^{-1}) was obtained from $N_0 \times V_2$ which was statistically similar to that of $N_0 \times V_1$ (Table 1; 2). Similar results were reported by Al- Halepyati (2001).

***Grain yield (t ha^{-1})*:** Statistically comparison of means in case of nitrogen levels showed that the grain yield increased significantly with increasing nitrogen levels (Table 1, 2). The highest value for grain yield (4.59 t ha^{-1}) was obtained from treatment N_3 (150 kg N ha^{-1}) which was statistically at par with treatment N_2 (100 kg N ha^{-1}) that produced the grain yield of (4.47 t ha^{-1}) but significantly differ than the grain yield of (3.84 t ha^{-1}) and (2.75 t ha^{-1}) for treatment N_1 (50 kg N ha^{-1}) and N_0 (control), respectively. These results are quite in line with Khan *et al.*, (2000); Nazir *et al.* (2000), Jan *et al.* (2002) and Patil and Intal (2002). Out of the three varieties, the maximum grain yield (4.49 t ha^{-1}) was achieved from V_3 (Uqab-2000) compared to the grain yield of (3.72 t ha^{-1}) and (3.53 t ha^{-1}) for varieties V_2 (Fareed-2006) and V_1 (Punjnad-I) respectively. The higher grin yield of V_3 (Uqab-2000) is attained due to greater number of total tillers and highest 1000-grain weight as compared to Punjnad-I and Fareed-2006. The interactive study was found to be highly significant as the highest grain yield (5.23 t ha^{-1}) was recorded in treatment $N_2 \times V_3$ that was statistically at par with $N_3 \times V_3$ (5.00 t ha^{-1}). The treatment $N_3 \times V_1$ was also statistically at with $N_2 \times V_2$ and $N_2 \times V_1$ which on average produced (4.11 t ha^{-1}) of grain yield. The lowest grain yield (2.66 t ha^{-1}) was obtained from $N_0 \times V_2$ treatment ($P \leq 0.05$). These findings are in conformity with those of Ghosh *et al.* (1996) and Maqsood *et al.* (2012a,b).

***Harvest index (%)*:** The physiological efficiency of the wheat plants to convert dry matter into grin yield is measured in terms of harvest index. The statistical results (Table 1; 2) showed that the highest harvest index value (36.17%) was obtained at treatment N_3 (150 kg N ha^{-1})

compared to N_0 (control) (31.53%) but it was statistically at par with N_2 (100 kg N ha^{-1}), which produced the harvest index value of (35.13 %). These treatments significantly differed with treatment N_1 (50 kg N ha^{-1}) and N_0 (control). Differences for the straw yield are in harmony with reported by Semenov *et al.* (2007). Comparison of means in case of varieties showed that the harvest index increased significantly with increasing levels of nitrogen. The highest value for harvest index (34.55%) was obtained from V_2 (Fareed-2006) which was statistically at par with V_1 (Punjnad-I) that produced the harvest index value of (33.70%) but the V_2 (Fareed-2006) significantly differed from V_3 (Uqab-2000), which produced the lowest value (33.21 %) of harvest index. The statistical results from interaction study was also found to be significant as the combination $N_2 \times V_2$ produced the maximum value (38.41%) for harvest index, in contrast to the lowest value (31.32%) in combination $N_1 \times V_1$ ($P \leq 0.05$). These finding are similar to the results of Maqsood *et al.* (2002) who reported that application of 150 kg N ha^{-1} to wheat gave the highest value of harvest index.

***Conclusions*:** Adequate nitrogen nutrition is most important constraint in producing a good wheat establishment. Nitrogen is needed at high concentrations in the plants at critical growth stages to obtain maximum yield. On the basis of results, it is suggested that wheat variety V_3 (Uqab-2000) was proved to be high yielding and 150 kg N ha^{-1} is the most suitable fertilizer level to achieve higher grain yield of wheat.

REFERENCES

Ali, A., M.A. Choudhry, M.A. Malik, R. Ahmad and Saifullah. 2000. Effect of various doses of nitrogen on the growth and yield of two wheat cultivars. Pak. J. Biol. Sci. 3: 1004-1005.

Ali, E.A. 2011. Impact of nitrogen application time on grain and protein yields as well as nitrogen use efficiency of some two-row barley cultivars in sandy soil. American-Eurasian J. Agric. Environ. Sci. 10: 425-433.

Ashour, N.I. and A.K. Haleem. 1995. A comparative study on wheat production in-upstream of dykes at wadu El-Arish in North Sinai. Bulletin Faculty Agri. Univ. Cario, Egypt. 46: 55-64.

Basit, A. 1996. Studies in N use efficiency in wheat by split application at different growth stages. M.Sc. (Hons.) Agri. Thesis, Uni. Agri. Faisalabad.

Dawson, J.C., D.R. Huggins and S.S. Jones. 2008. Characterizing nitrogen use efficiency in natural and agricultural ecosystems to improve the performance of cereal crops in low-input and organic agricultural systems. Field Crop Res. 107: 89-101.

Frink, C.R., P.E. Waggoner and J.H. Ausubel. 1999. Nitrogen fertilizer: etrospect and prospect. Proc. Nat. Acad. Sci., U.S.A. 96:1175-1180.

Gwal, H.B., R.J. Tiwari, R.C. Jain and F.S. Prajapati. 1999. Effect of different levels of fertilizer on growth, yield and quality of late sown wheat. RACHIS Newsletter, 18:42-44.

GOP. 2012. Economic Survey of Pakistan. 2011-12. Ministry of Food, Agriculture and Livestock, Federal Bureau of Statistics, Islamabad. p. 21.

Ghosh, A., D. Chandra and N. Sahoo. 1996. Seasonal influence of new wheat varieties grown at different nitrogen levels. Ind. J. Agri. Sci. 66:708-710.

Guo, S., T. Dang and D. Hao. 2005. Effects of fertilization on wheat yield, NO_3-N accumulation and soil water content in semi arid area of China. Scientia Agri. Sin. 38:754-760.

Hameed, E.W., A. Shah, A.A. Shad, J. Bakhat and T. Muhammad. 2003. Effect of different planting dates, seed rates and nitrogen levels on wheat. Asian J. Plant Sci. 2:467-474.

Halepyati, A.S. 2001. Influence of irrigation and nitrogen levels on growth and yield of wheat. Karnataka J. Agric. Sci. 14:449-450.

Iqbal, J., K. Hayat, S. Hussain. 2012. Effect of seeding rates and nitrogen levels on yield and yield components of wheat (*Triticum aestivum* L.). Pak. J. Nut. 11:531-536.

Islam, Z.U., S. Khan, J. Bakhat and W.A. Shah. 2002. Frequency of various nitrogen levels, lodging and seed quality in wheat. Asian J. Plant Sci. 1:510-512.

Jan, M.T., M. Shah and S. Khan. 2002. Type of nitrogen fertilizer rate and timing effect on wheat production. Sarhad J. Agri. 18:405-410.

Kaliq, A., M. Iqbal and S.M.A. Basra. 1999. Optimization of seedling density and nitrogen application in wheat cv. Inqlab-91 under Faisalabad conditions. Int. J. Agri. Biol. 1:241-243.

Khan, S., N.D. Shah and M.T. Sheikh. 2000. Effect and economics of different levels of nitrogen fertilizer on the yield of zargoon wheat variety under irrigated conditions of Baluchistan. Sarhad J. Agri. 16:581-585.

Li, X., C. Hu., J.A. Delgado, Y. Zhang and Z. Ouyang. 2007. Increased nitrogen use efficiencies as a key mitigation alternative to reduce nitrate leaching in North China plain. Agri. Water Manag. 89:137-147.

Makowski, D., D. Wallach and J.M. Meynard. 1999. Model of yield, grain protein and residual mineral nitrogen responses to applied nitrogen for winter wheat. Agron. J. 91:337-385.

Maqsood, M., A. Ali., Z. Aslam, M. Saeed and S. Aslam. 2002. Effect of irrigation and nitrogen levels on grain yield and quality of wheat. Int. J. Agri. Bio. 4:164-165.

Maqsood, M., M.A. Shehzad, S. Ahmad and S. Mushtaq. 2012a. Performance of wheat (*Triticum aestivum* L.)

genotypes associated with agronomical traits under water stress conditions. Asian. J. Pharm. Biol. Res. 2: 45-50.

Muchow, R.C. and T.R. Sinclair. 1994. Nitrogen response of leaf photosynthesis and canopy radiation use efficiency in field-grown maize and sorghum. Crop Sci. 34:721-727.

Maqsood, M., M.A. Shehzad, M.A. Sarwar, H.T. Abbas and S. Mushtaq. 2012b. Impact of different moisture regimes and nitrogen rates on yield and yield attributes of maize (*Zea mays* L.). Afr. J. Biotechnol. 11:8449-8455.

Naeem, M. 2001. Growth, radiation use efficiency and yield of new cultivars of wheat under variable nitrogen rates. M.Sc. (Hons.) Agri. Thesis, Dept. Agronomy, Univ. Agri., Faisalabad.

Nazir, M.S., A. Jabbar, Z. Waheed, A. Gaffar and M. Aslam. 2000. Response of late sown wheat to seeding density and nitrogen management. Pak. J. Biol. Sci. 3:998-1001.

Patil, R.H. and C.J. Intal. 2002. Nitrogen uptake and grain protein in emmer wheat genotype as influenced by sowing dates and nitrogen levels. Karnataka J. Agric. Sci. 15: 349-352.

Rafiq, M.A., A. Ali, M.A. Malik and M. Hussain. 2010. Effect of fertilizer levels and plant densities on yield and protein contents of autumn planted maize. Pak. J. Agri. Sci. 47:201-208.

Raun, W.R. and G.V. Johnson. 1999. Improving nitrogen use efficiency for cereal production. Agron. J. 91:357-363.

Shehu, H.E., J.D. Kwari AND M.K. Sandabe. 2010. Effects of N, P and K fertilizers on yield, content and uptake of N, P and K by Sesame (*Sesamum indicum*). Int. J. Agric. Biol. 12: 845-850.

Shehzad, M.A., M.A. Nadeem, M.A. Sarwar, G.M. Naseer-ud-Din and F. Ilahi. 2012a. Comparative efficacy of different post-emergence herbicides in wheat (*Triticum aestivum* L.). Pak. J. Agri. Sci. 49:27-34.

Shehzad, M.A., M. Maqsood, M. Anwar-ul-Haq, A. Niaz (2012b). Efficacy of various herbicides against weeds in wheat (*Triticum aestivum* L.). Afr. J. Biotechnol. 11:791-799.

Sinclair, T.R. 1990. Nitrogen influence on the physiology of crop yield. pp. 41-55. In: R. Rabbinge, J. Goudriaan, H. van Keulen, F.W.T. Penning de Vries and H.H. van Laar (eds.), Theoretical Production Ecology: Reflection and Prospects. Pudoc, Wageningen.

Shehzad, M.A., M. Maqsood, M.A. Bhatti, W. Ahmad and M.R. Shahid. 2012c. Effects of nitrogen fertilization rate and harvest time on maize (*Zea mays* L.) fodder yield and its quality attributes. Asian. J. Pharm. Biol. Res. 2:19-26.

Steel, R.G.D., J.H. Torrie and D.A. Dicky. 1997. Principles and Procedures of Statistics, A biometrical approach. 3rd Ed. McGraw Hill, Inc. Book Co. Inc. New York, U.S.A. pp. 172-177.

Saren, B.K. and P.K. Jana. 2001. Effect of depth of irrigation and level and time of nitrogen application on growth, yield and nutrient uptake by wheat. Ind. J. Agron. 46: 227-232.

Sabir, S., J. Bakht, M. Shafi and W.A. Shah. 2002. Effect of foliar vs. Broad cast application of different doses of nitrogen on wheat. Asian J. Plant Sci. 1:300-303.

Semenov, M.A., P.D. Jamieson and P. Martre. 2007. Deconvoluting nitrogen use efficiency in wheat: A simulation study. Europ. J. Agron. 26:283-294.

Tisdale, S.L., W.L. Nelson and J.D. Beaton. 1990. Soil Fertility and Fertilizers. MacMillan Pub. Co., New York, pp. 60-62.

Wuest, S.B. and K.G. Cassman. 1992. Fertilizer nitrogen use efficiency of irrigated wheat. Uptake efficiency of preplant versus late season application. Agron. J. 84: 682-688.