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EFFECT OF FOLIAR VS SOIL APPLICATION OF NITROGEN ON YIELD AND YIELD COMPONENTS OF WHEAT VARIETIES

JEHAN BAKHT[1*], MOHAMMAD SHAFI[2] MOHAMMAD ZUBAIR[2], MOHAMMAD AMAN[3] KHAN AND ZAHIR SHAH[4]

[1]Institute of Biotechnology and Genetic Engineering, Agricultural University, Peshawar KPK Pakistan
[2]Department of Agronomy, Agricultural University, Peshawar, KPK Pakistan
[3]LRH, Peshawar, KPK Pakistan
Department of SES, Agricultural University, Peshawar KPK Pakistan
**Corresponding author: E-mail: jehanbakht@yahoo.co.uk*

Abstract

The present study was carried out at the farms of Agricultural University Peshawar, KPK Pakistan during 2007. Experiments were conducted using RCB design with split plot arrangements, having four replications. Different wheat varieties viz., Uqab 2000, Saleem 2000 and Pirsabak 2004 while nitrogen levels (0, tap water, 90 kg ha^{-1} in soil, 120 kg ha^{-1} in soil, 150 kg ha^{-1} in soil, 90 kg ha^{-1}($2/3^{rd}$ soil + $1/3^{rd}$ foliar), 120 kg ha^{-1}($2/3^{rd}$ soil + $1/3^{rd}$ foliar) and 150 kg ha^{-1}($2/3^{rd}$ soil + $1/3^{rd}$ foliar) to subplots were used. Days to heading and maturity, plant height, productive and non productive tillers m^{-2} , spike length, grains $spike^{-1}$, 1000 grain weight and grain yield was significantly ($p<0.05$) affected by different varieties, nitrogen levels and method of N application. Nitrogen concentration in straw and grain was significantly ($p<0.05$) affected by different nitrogen levels and method of N application. Significantly higher grain yield was produced by Pirsabak 2004 when compared with other varieties. In case of N levels, maximum grain yield was produced by treatments fertilized with highest dose of foliar N.

Introduction

It is well recognized that inputs like optimum sowing time, seeding density and balance fertilizer each has an effective role in increasing the yield of many crops including wheat. For growing healthy plants, there is a need to provide balance nutrition to the plants for which an integrated management is an essential part. Farmers either apply no nitrogen or apply nitrogen fertilizer exorbitantly that could cause imbalance in the nutrient supply. The trend in fertilizer use is mostly driven by the need of developing countries to keep food supply up with population growth. It has been projected that by the year 2025, world population will be more than 8 billion people, with more than 90% of this additional growth concentrated in developing countries. Foliar fertilization is a widely used practice to correct nutritional deficiencies in plants caused by improper supply of nutrient to roots (Ling & Silberbush, 2002). Woolfolk *et al*., (2002) reported that a significant linear increase in total grain N was observed for post flowering foliar applications in five of six site-years. Similarly, Roxana *et al*., (2003) observed that spike N content was higher in the N fertilized plants. Number of grains was positively associated with spike N and P content as well as spike dry matter at heading. Number of grains per unit of spike dry matter at heading in N fertilized micro crops tended to be higher than in N stressed ones. Foliar applied N tended to increase seed yield of soybean, cotton and rap-seed-mustard (Oko *et al*., 2003; Siddique *et al*., 2008; Wiedenfeld *et al*.,

2009). In this paper we report the effect of foliar vs soil application of nitrogen on yield and yield components of wheat varieties.

Materials and Methods

The present study was conducted at the New Developmental Farm (NDF) of Agricultural University Peshawar, KPK Pakistan during winter 2007 to investigate the effect of methods and levels of nitrogen application on the performance of different wheat varieties. The experiment was carried out in randomized complete block design (RCB) with split plot arrangements, having four replications. Three wheat varieties viz., Uqab 2000, Saleem 2000 and Pirsabak 2004 while nitrogen levels (0, normal water, 90 kg ha^{-1} in soil, 120 kg ha^{-1} in soil, 150 kg ha^{-1} in soil, 90 kg ha^{-1}($2/3^{rd}$ soil + $1/3^{rd}$ foliar), 120 kg ha^{-1}($2/3^{rd}$ soil + $1/3^{rd}$ foliar) and 150 kg ha^{-1} ($2/3^{rd}$ soil + $1/3^{rd}$ foliar) was alloted to subplots. Each subplot had a net area of 1.8 m x 3 m having 6 rows, 30 cm apart. A basal dose of 90-60 kg PK ha^{-1} was applied at the time of sowing. For soil application of N, half dose of 90, 120 and 150 kg N ha^{-1} was applied at sowing time while the remaining half at second irrigation. In case of soil cum foliar application of N, $2/3^{rd}$ of 90, 120 and 150 kg N ha^{-1} at two different stages i.e., half at sowing and half at second irrigation to the soil was used. The remaining $1/3^{rd}$ of 90, 120 and 150 kg N ha^{-1} was sprayed in three split doses i.e., before tillering (end of January), tillering (mid of February) and booting (mid of March). Water spray was used to analyze the effect of water in case of foliar. Before sowing a composite soil sample was taken for nitrogen analysis (42.61 µg g^{-1} at 0-15 cm depth and 36.32 µg g^{-1} at 15-30 cm depth). Recommended agronomic practices i.e., irrigation, weeding, hoeing was carried out uniformly for all the treatments to exploit full potential of treatments.

Plant height was noted by measuring the height of 10 representative plants in each sub-plot. Days to heading data was collected from the date of sowing till when 80% heads emerged in each sub-plot. Days to maturity data were recorded from the date of sowing till when all the plants got matured. The data on number of productive tillers m^{-2} was recorded in an area of one square meter. Data on non-productive tillers m^{-2} was recorded as described for productive tillers m^{-2}. In case of spike length or ear length, spikes of 10 randomly tagged tillers were measured from the basal joint of the spike till the terminal spike excluding the awns. To record grain $spike^{-1}$, ten earmarked spikes were threshed and their grains were counted. Thousand grains were counted from threshed clean grain of each treatment. Biological yield was calculated after harvesting two central rows in each sub-plot, dried and weighed. Grain yield was recorded for each sub-plot after threshing and then converted into kg ha^{-1}. Nitrogen concentration in straw and grain was determined according to the methods of Bremner & Mulvaney (1982).

All data are presented as mean values of three replicates. Data were analyzed statistically for analysis of variance (ANOVA) following the method described by Gomez & Gomaz (1984). MSTATC computer software was used to carry out statistical analysis (Russel & Eisensmith, 1983). The significance of differences among means was compared by using Least Significant Difference (LSD) test (Steel & Torrie, 1997).

Table 1. Days to heading of wheat varieties as affected by different nitrogen levels and method of N application

Treatments N Levels (kg ha^{-1})	Varieties			
	Uqab 2000	**Saleem 2000**	**Pirsabak 2004**	**Mean**
0	124.25	123.75	122.75	123.58 c
H_2O	125.00	124.50	122.50	124.00 c
90 (S)	126.75	126.25	122.75	125.25 b
120 (S)	127.25	126.75	122.50	125.50 b
150 (S)	128.50	129.50	122.75	126.92 a
90 (2/3rd S + 1/3rd F)	126.50	126.00	122.00	124.83 b
120 (2/3rd S + 1/3rd F)	128.75	128.00	122.25	126.33 a
150 (2/3rd S + 1/3rd F)	129.25	128.50	122.25	126.67 a
Mean	**127.03 a**	**126.66 a**	**122.47 b**	

Table 2. Days to maturity of wheat varieties as affected by different nitrogen levels and method of N application

Treatments N Levels (kg ha^{-1})	Varieties			
	Uqab 2000	**Saleem 2000**	**Pirsabak 2004**	**Mean**
0	162.3	161.8	160.8	161.6 c
H_2O	163.0	162.5	160.5	162.0 c
90 (S)	164.8	164.3	160.8	163.3 b
120 (S)	165.3	164.8	160.5	163.5 b
150 (S)	166.5	167.5	160.8	164.9 a
90 (2/3rd S + 1/3rd F)	164.5	164.0	160.0	162.8 b
120 (2/3rd S + 1/3rd F)	166.8	166.0	160.3	164.3 a
150 (2/3rd S + 1/3rd F)	167.3	166.5	160.3	164.7 a
Mean	**165.0 a**	**164.7 a**	**160.5 b**	

Mean values followed by different letters are statistically different at $p<0.05$ using LSD test.
S = Soil, F = Foliar

Results and Discussion

Days to heading and maturity were significantly ($p<0.05$) affected by different varieties, nitrogen levels, method of N application as well as their interaction. More days to heading were recorded when highest rate of nitrogen was applied (Tables 1 & 2). Nitrogen accelerates vegetative growth which delayed days to heading. Similarly, foliar application of nitrogen also delayed days to heading. This may be due to more availability and utilization of N. Maximum days to maturity were noted in Uqab 2000 sown plots when compared with other varieties (Table 2). In case of interaction, maximum days to maturity were taken by Saleem 2000 when treated with 150 kg N ha^{-1} in soil. Similar results are also reported by Ling & Silberbush (2002) and Siddiqui *et al*., (2008) who reported that foliar application of N significantly increased growth characteristics. Different varieties and various nitrogen levels had a significant ($p<0.05$) effect on plant height, while their interactions were non-significant. Taller plants were recorded in high N treatments (Table 3). The probable reason could be more vegetative growth at highest dose of nitrogen which could have resulted in taller plants. This may be due to greater and more efficient absorption of nitrogen, which could have resulted in taller plants. These results agree with those reported by Ling & Silberbush (2002) and Siddiqui *et al*., (2008).

Productive and non productive tillers m^{-2} were significantly ($p<0.05$) affected by different varieties, method of N application and nitrogen levels. The effect of various interactions was also significant ($p<0.05$) on non productive tillers m^{-2} (Tables 4 & 5). Maximum number of productive tillers m^{-2} was produced by Pirsabak 2004 when compared with other treatments. Highest N treatments resulted in increased number of productive tillers m^{-2} which was statistically at par with treatments fertilized with 120 kg N ha^{-1} ($2/3^{rd}$ soil + $1/3^{rd}$ foliar). The opposite trend was noted for non productive tillers m^{-2}. It may be due to the fact that nitrogen is an essential element for growth and development and thus promotes vegetative growth. Our results also indicated that foliar application of nitrogen increased number of productive tillers m^{-2}. Similar results are also reported by Ling & Silberbush (2002), Bly & Woodard (2003), Oko *et al*., (2003), Siddiqui *et al*., (2008) and Otteson *et al*., (2007 & 2008). Different varieties and nitrogen levels and method of N application had significantly ($p<0.05$) affected spike length, grains $spike^{-1}$, 1000 grain weight and grain yield while their interactions were non-significant (Tables 6-9). Maximum spike length was recorded in Uqab 2000 compared with other varieties. In case of N levels, maximum spike length was noted in foliar spray of nitrogen at the highest dose. Our data also suggested that maximum number of grains $spike^{-1}$ was observed in Pirsabak 2004, while in case of nitrogen, number of grains $spike^{-1}$ and thousand weight was maximum in treatment of 120 kg N ha^{-1} ($2/3^{rd}$ soil + $1/3^{rd}$ foliar). This may be due to the fact that maximum availability and absorption of nitrogen in case of foliar spray resulted in more grains $spike^{-1}$ and 1000 grain weight.

Our results also suggested that significantly higher grain yield was produced by Pirsabak 2004 when compared with other varieties. In case of N levels, maximum grain yield was produced by treatments fertilized with highest dose of foliar N which was statistically at par with treatments fertilized with 120 kg N ha^{-1} ($2/3^{rd}$ soil + $1/3^{rd}$ foliar) (Table 10). Similar results are also reported by Ling & Silberbush (2002), Woolfolk *et al*., (2002), Bly & Woodard (2003), Oko *et al*., (2003), Siddiqui *et al*., (2008) and Otteson *et al*., (2007 & 2008). Various nitrogen levels, method of N application and their interactions significantly ($p<0.05$) affected biological yield (Table 11) while different varieties had a non-significant effect. Highest biological yield was observed in highest nitrogen treatments in foliar form compared with other treatments (Table 11). These results agree with those reported by Woolfolk *et al*., (2002). Nitrogen levels and interaction between varieties and nitrogen levels had a significant ($p<0.05$) effect on nitrogen concentration in straw, while the effect of varieties was non-significant. All the three cultivars accumulated equal amount of nitrogen in their straw. In case of N levels, maximum nitrogen concentration in straw was recorded when treated with 150 kg N ha^{-1} in soil and 150 kg N ha^{-1} ($2/3^{rd}$ soil + $1/3^{rd}$ foliar). In case of interaction, maximum nitrogen concentration in straw was noted in Saleem 2000 when fertilized with 150 kg N ha^{-1} ($2/3^{rd}$ soil + $1/3^{rd}$ foliar) compared with other treatments. It is also clear from the data that nitrogen levels had a significant ($p<0.05$) effect on nitrogen concentration in grain, while different varieties and interaction between varieties and nitrogen levels had a non-significant effect (Table 12). Higher nitrogen concentration in grain was recorded in plots sown with Saleem 2000. Similarly, maximum nitrogen concentration in grain was recorded by plants treated with 150 kg N ha^{-1} ($2/3^{rd}$ soil + $1/3^{rd}$ foliar. Maximum nitrogen concentration in grain was recorded by plots sown with Saleem 2000 and treated with 150 kg N ha^{-1} ($2/3^{rd}$ soil + $1/3^{rd}$ foliar). These results agree with those reported by Bly & Woodard (2003) and Subedi *et al*., (2007).

Table 3. Plant height (cm) of wheat varieties as affected by different nitrogen levels and method of N application

Treatments N Levels (kg ha^{-1})	Varieties			
	Uqab 2000	**Saleem 2000**	**Pirsabak 2004**	**Mean**
0	80.75	79.25	78.50	79.50 d
H_2O	83.50	80.50	81.25	81.75 d
90 (S)	87.50	84.00	85.50	85.67 c
120 (S)	91.25	86.75	89.00	89.00 bc
150 (S)	94.50	89.50	90.25	91.42 ab
90 (2/3rd S + 1/3rd F)	93.00	85.50	91.50	90.00 ab
120 (2/3rd S + 1/3rd F)	94.75	90,00	93.00	92.58 ab
150 (2/3rd S + 1/3rd F)	95.25	90,50	94.00	93.25 a
Mean	**90.06 a**	**85.75 b**	**87.88 ab**	

Table 4. Number of productive tiller m^{-2} of wheat varieties as affected by different nitrogen levels and method of N application

Treatments N Levels (kg ha^{-1})	Varieties			
	Uqab 2000	**Saleem 2000**	**Pirsabak 2004**	**Mean**
0	239.50	230.80	244.30	238.20 e
H_2O	238.30	239.80	245.30	241.10 e
90 (S)	270.80	260.00	286.30	272.30 d
120 (S)	282.00	276.50	296.80	285.10 bc
150 (S)	290.50	283.30	310.30	294.70 ab
90 (2/3rd S + 1/3rd F)	274.80	276.00	281.80	277.50 cd
120 (2/3rd S + 1/3rd F)	292.50	294.50	306.80	297.90 a
150 (2/3rd S + 1/3rd F)	300.50	289.30	314.50	301.40 a
Mean	**273.60 b**	**268.80 b**	**285.70 a**	

Mean values followed by different letters are statistically different at $p<0.05$ using LSD test.
S = Soil, F = Foliar

Table 5. Number of non productive tiller m^{-2} of wheat varieties as affected by different nitrogen levels and method of N application

Treatments N Levels (kg ha^{-1})	Varieties			
	Uqab 2000	**Saleem 2000**	**Pirsabak 2004**	**Mean**
0	39.75	41.50	38.00	39.75 a
H_2O	42.50	43.25	40.50	42.08 a
90 (S)	25.50	25.00	19.00	23.17 bc
120 (S)	23.50	23.75	20.75	22.67 bc
150 (S)	28.25	22.75	20.75	23.92 b
90 (2/3rd S + 1/3rd F)	24.00	24.25	21.50	23.25 bc
120 (2/3rd S + 1/3rd F)	20.50	19.75	19.25	19.83 c
150 (2/3rd S + 1/3rd F)	20.00	19.50	19.50	19.67 c
Mean	**28.00**	**27.47**	**24.91**	

Table 6. Spike length (cm) of wheat varieties as affected by different nitrogen levels and method of N application

Treatments N Levels (kg ha^{-1})	Varieties			
	Uqab 2000	**Saleem 2000**	**Pirsabak 2004**	**Mean**
0	8.50	7.95	8.45	8.30 d
H_2O	8.75	8.00	8.50	8.42 d
90 (S)	10.00	8.75	9.00	9.25 c
120 (S)	10.25	9.13	9.50	9.63 c
150 (S)	11.50	9.50	10.25	10.42 b
90 (2/3rd S + 1/3rd F)	10.75	10.00	10.50	10.42 b
120 (2/3rd S + 1/3rd F)	10.63	10.25	10.50	10.46 b
150 (2/3rd S + 1/3rd F)	12.25	11.00	11.50	11.58 a
Mean	**10.33 a**	**9.32 c**	**9.78 b**	

Mean values followed by different letters are statistically different at $p<0.05$ using LSD test.
S = Soil, F = Foliar

Table 7. Number of grain spike^{-1} of wheat varieties as affected by different nitrogen levels and method of N application

Treatments N Levels (kg ha^{-1})	Varieties			
	Uqab 2000	**Saleem 2000**	**Pirsabak 2004**	**Mean**
0	46.25	44.00	49.25	46.50 e
H_2O	47.75	47.00	50.00	48.25 e
90 (S)	50.75	50.25	53.25	51.42 d
120 (S)	51.75	51.00	53.75	52.17 cd
150 (S)	53.75	52.25	54.25	53.42 bcd
90 (2/3rd S + 1/3rd F)	54.25	52.75	55.25	54.08 bc
120 (2/3rd S + 1/3rd F)	56.50	55.00	57.25	56.25 a
150 (2/3rd S + 1/3rd F)	55.00	53.50	55.25	54.58 ab
Mean	52.00 ab	50.72 b	53.53 a	

Table 8. Thousand grain weight (g) of wheat varieties as affected by different nitrogen levels and method of N application

Treatments N Levels (kg ha^{-1})	Varieties			
	Uqab 2000	**Saleem 2000**	**Pirsabak 2004**	**Mean**
0	38.45	39.08	39.90	39.14 d
H_2O	39.40	38.70	40.93	39.68 cd
90 (S)	40.90	39.85	42.98	41.24 bc
120 (S)	41.48	40.68	42.23	41.46 b
150 (S)	42.73	40.05	42.80	41.86 ab
90 (2/3rd S + 1/3rd F)	41.98	40.90	40.93	41.27 bc
120 (2/3rd S + 1/3rd F)	44.35	41.58	43.85	43.26 a
150 (2/3rd S + 1/3rd F)	40.48	39.75	42.70	40.98 bc
Mean	**41.22**	**40.07**	**42.04**	

Mean values followed by different letters are statistically different at $p<0.05$ using LSD test.
S = Soil, F = Foliar

Table 9. Grain yield (kg ha^{-1}) of wheat varieties as affected by different nitrogen levels and method of N application

Treatments N Levels (kg ha^{-1})	Varieties			
	Uqab 2000	**Saleem 2000**	**Pirsabak 2004**	**Mean**
0	2006.75	1970.25	2136.00	2037.67 d
H_2O	2100.50	2019.75	2258.50	2126.25 d
90 (S)	3250.00	3029.00	3365.25	3214.75 c
120 (S)	3443.00	3224.75	3555.00	3407.58 b
150 (S)	3504.00	3403.00	3631.25	3512.75 b
90 (2/3rd S + 1/3rd F)	3474.25	3372.75	3475.50	3440.83 b
120 (2/3rd S + 1/3rd F)	3642.75	3473.50	3921.00	3679.08 a
150 (2/3rd S + 1/3rd F)	3725.25	3511.50	3959.25	3732.00 a
Mean	**3143.31 b**	**3000.56 c**	**3287.72 a**	

Table 10. Biological yield (kg ha^{-1}) of wheat varieties as affected by different nitrogen levels and method of N application

Treatments N Levels (kg ha^{-1})	Varieties			
	Uqab 2000	**Saleem 2000**	**Pirsabak 2004**	**Mean**
0	6147.50	5142.50	5142.50	5477.50 c
H_2O	6134.00	5488.75	5126.50	5583.08 c
90 (S)	7972.00	8294.00	8439.25	8235.08 b
120 (S)	8200.00	8132.00	8209.75	8180.58 b
150 (S)	8721.50	9017.50	8421.50	8720.17 a
90 (2/3rd S + 1/3rd F)	8691.75	8577.50	8636.25	8635.17 a
120 (2/3rd S + 1/3rd F)	8263.50	8334.50	8683.75	8427.25 ab
150 (2/3rd S + 1/3rd F)	8397.25	8526.00	8965.25	8629.50 a
Mean	7815.94	7689.09	7703.09	

Mean values followed by different letters are statistically different at $p<0.05$ using LSD test.
S = Soil, F = Foliar

Table 11. Nitrogen concentration in straw (%) of wheat varieties as affected by different nitrogen levels and method of N application

Treatments N Levels (kg ha^{-1})	Varieties			
	Uqab 2000	**Saleem 2000**	**Pirsabak 2004**	**Mean**
0	0.46	0.47	0.48	0.47 e
H_2O	0.47	0.48	0.50	0.48 d
90 (S)	0.50	0.49	0.51	0.50 c
120 (S)	0.53	0.51	0.50	0.51 b
150 (S)	0.51	0.52	0.53	0.52 a
90 (2/3rd S + 1/3rd F)	0.50	0.51	0.50	0.50 c
120 (2/3rd S + 1/3rd F)	0.51	0.52	0.50	0.51 b
150 (2/3rd S + 1/3rd F)	0.51	0.54	0.50	0.52 a
Mean	0.50	0.50	0.50	

Table 12. Nitrogen concentration in grain (%) of wheat varieties as affected by different nitrogen levels and method of N application

Treatments N Levels (kg ha^{-1})	Varieties			
	Uqab 2000	**Saleem 2000**	**Pirsabak 2004**	**Mean**
0	2.24	2.26	2.33	2.28 c
H_2O	2.26	2.35	2.34	2.32 bc
90 (S)	2.35	2.35	2.36	2.35 ab
120 (S)	2.35	2.41	2.31	2.36 ab
150 (S)	2.43	2.36	2.32	2.37 ab
90 (2/3rd S + 1/3rd F)	2.41	2.34	2.34	2.36 ab
120 (2/3rd S + 1/3rd F)	2.33	2.40	2.37	2.37 ab
150 (2/3rd S + 1/3rd F)	2.42	2.45	2.34	2.40 a
Mean	2.35	2.36	2.34	

Mean values followed by different letters are statistically different at $p<0.05$ using LSD test.
S = Soil, F = Foliar

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