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Effect of Seeding Rates and Nitrogen Levels on Yield and Yield Components of Wheat (*Triticum aestivum* L.)

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Abstract: A field experiment to investigate the effect of seeding rates and different levels of nitrogen on yield and yield components of wheat was conducted at Research Area, College of Agriculture, Dera Ghazi Khan. An approved cultivar Fareed-2006 was sown at seeding rates of 125, 150 and 175 kg/ha with five nitrogen levels of 0, 75, 100, 125 and 150 kg N/ha. Experiment was laid out in Randomized Complete Block Design (RCBD) with split plot arrangement keeping seed rate in main plots and nitrogen levels in sub plots having three replications while, net plot size was 3 x 7 m^2. Yield components such as plant height (cm), spike length (cm), number of spikelets/spike, number of grain/spike, 1000-grain weight (g), biological yield (kg/ha), grain yield (kg/ha) and harvest index were maximum at seeding rate of 150 kg/ha and minimum at seeding rate of 125kg/ha while number of tillers were maximum at seeding rate of 175 kg/ha and minimum at seeding rate of 125kg/ha. Similarly plant height, number of tillers m^{-2}, spike length, number of spikelets/spike, number of grain/spike, 1000-grain weight, grain yield, biological yield and harvest index were highest at nitrogen at 125 kg/ha and lowest at zero level of nitrogen. The interaction between seeding rates and nitrogen levels was found non significant for plant height, number of tillers m^{-2} spike length, number of spikelets/spike and 1000 grain weight while a significant interaction was noted for number of grain/ spike, grain yield, biological yield and harvest index and were maximum at seeding rate of 150 kg/ha with nitrogen level of 125 kg/ha.

Key words: Seed rate, wheat, nitrogen, yield components

INTRODUCTION

Agriculture sector being the important component of the country's economy and continues to be the single largest sector that is acting as a dominant driving for growth and development of the national economy. Since the time of independence Pakistan has been trying its best to provide the basic requirements of its people through sufficient wheat production. Although wheat production of Pakistan is increasing sufficiently but the average per acre yield in Pakistan (2639 kg/ha; Govt. of Pakistan, 2010) is far below than the world's average and that of developed countries of the world such as Germany (7282 kg/ha), Egypt (6251 kg/ha), Mexico (4404 kg/ha) and China (3729 kg/ha) (FAO, 2002). Even with in the country there is much difference in yield gap in average (2639 kg/ha) as compared to the potential (7200 kg/ha) of our existing wheat varieties. It is desired to have higher yield per unit area to meet the increasing demand of food grain for rapidly growing population of the country. The main factors responsible for low yield are less or more plant population and inadequate crop nutrition.

Plant density is a major factor determining the ability of the crop to capture resources and generate yield. It can be developed by using a suitable seeding rate. Growth and yield of wheat are affected by environmental conditions and can be regulated by sowing time and seeding rate (Ozturk *et al*., 2005). Maximum genetic potential of high yielding wheat varieties cannot be harvested without ensuring proper seeding rate. It is of particular importance in wheat production because it is under the farmers control in most cropping systems (Satorre, 1999). Consequently, there is value in defining relationships between density, tiller production and wheat yield to establish optimum seeding rates for various regions (Anderson and Sawkins, 1997).

As the plant density increases, the competition for resources especially for nitrogen also increases that badly affect the ultimate yield. Provision of additional nitrogen can be hypothesized to further enhance the yield by increasing plant population but up to an optimum level. Further higher nitrogen can lead to the lodging of plants at higher seed rate (Nazir *et al*., 2000). 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 availability is essential in the form of chemical fertilizers. Proper use of nitrogen is also considered for farm profitability and environment protection (Makowski

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et al., 1999). The research work done indicates that appropriate level of nitrogen application has increased wheat yield significantly (Gwal *et al.*, 1999; Ali *et al.*, 2000). Among all the essential nutrients applied in the field, nitrogen is the most important for vegetative crop growth, plant productivity and grain quality (Frink *et al.*, 1999).

The efficient utilization of nitrogen by wheat and other cereals has become increasingly important because of increased cost associated with the manufacturing and distribution of fertilizers. Increased use of nitrogen in agricultural production has raised concerns because of the risk for groundwater contamination. These concerns have advised the farmers to use nitrogen more efficiently. Nitrogen use efficiency may prove to be a mitigation alternative to reduce leaching (Li *et al.*, 2007). Routes to the improvement of nitrogen use efficiency may be through selection of an appropriate environment for the crop, appropriate variety (Chaudhary and Mehmood, 1998), better management and crop genetic improvement. However, the relative importance of these choices is poorly understood (Semenov *et al.*, 2007).

The presented research was conducted with the objective to have an optimum crop stand with an optimum nitrogen use under arid condition of Dera Ghazi Khan.

MATERIALS AND METHODS

A study to examine the effect of seeding rates and different levels of nitrogen was conducted at research Area College of Agriculture, Dera Ghazi Khan during winter 2010. An approved cultivar Fareed-2006 obtained from Ayub Agriculture Research Institute, Faisalabad was sown at seeding rates of 125, 150 and 175 kg/ha with five nitrogen levels of 0, 75, 100, 125 and 150 kg N/ha. The experiment was laid out in Randomized Complete Block Design (RCBD) with split plot arrangement placing seeding rate in main plot and fertilizer in sub plots with three replications. The net plot size was 3x7 m^2. Seed bed was prepared by Ploughing the field for 3 times with cultivator followed by planking. Wheat crop was sown manually with single row hand drill by maintaining row to row distance of 25 cm. Before sowing, soil was analyzed for its physico-chemical properties and found 0.66% organic matter, 2.78 ppm available phosphorus, 90 ppm available Potassium with 2.31 dSm^{-1} EC and 7.83 pH. The nitrogen fertilizer in the form of urea was applied as per treatments in three splits i.e., one third at the time of sowing and remaining nitrogen was applied at the time of first and second irrigation. All plots received uniform cultural practices other than treatments. Data about yield and its different components were recorded as per recommended procedure. The recorded data were analyzed statistically by using statistical software package," MSTATC". Duncan Multiple Range Test at level of 0.05 probabilities was employed to compare the differences among the treatments means (Steel *et al.*, 1997).

RESULTS AND DISCUSSION

Plant height: Plant height was statistically affected by seeding rate and nitrogen levels (Table 1). Tallest plants (98.33 cm) were observed at seeding rate of 150 kg/ha while smallest plants (94.33 cm) were recorded at seeding rate of 175 kg/ha and was statistically similar (94.99 cm) to seeding rate of 125 kg/ha (Table 2). Nitrogen fertilization also has pronounced effect on plant height of wheat cv. Fareed-2006 (Table 2). Tallest plants were observed at nitrogen level of 125 kg/ha followed by 100 kg/ha and 150 kg/ha while smallest plants were recorded at zero level of nitrogen. The interaction of seeding rate and nitrogen levels were found non significant (Table 3). However, comparatively taller plants were observed at seeding rate of 150 kg/ha with 125 kg/ha nitrogen. The research findings are in coordinate with Lafond (1994); Geleta *et al.* (2002). Ali *et al.* (1996) studied that maximum plant height was obtained at a seeding rate of 125 kg/ha. Chandra *et al.* (1992) concluded that plant height increased significantly by increasing nitrogen levels.

Number of tillers m^{-2}: Crop yields are generally dependent upon many yield contributing agents. Among these number of tillers are the most important because of the contribution in final yield. Numbers of tillers per unit area of the wheat were statistically affected by seeding rate and nitrogen levels (Table 1). More number of tillers (503.40) was observed at seeding rate of 175 kg/ha while less number of tillers (404.40) was recorded at seeding rate of 125 kg/ha and was statistically less (464.6) from seeding rate of 150 kg/ha (Table 2). Number of tillers was also affected by nitrogen fertilization (Table 1). Maximum numbers of tillers were observed at nitrogen level of 125 kg/ha followed by 150 kg/ha and 100 kg/ha (Table 2). At zero level of nitrogen minimum numbers of tillers (434.56) were recorded. Non significant interaction was found between seeding rates and nitrogen levels (Table 3). However at seeding rate of 175 kg/ha and 125 kg/ha nitrogen more number of tillers was observed. Increase in number of tillers per unit area is due to increased seeding rate (Ahmad *et al.*, 2000; Khan *et al.*, 2000; Hussain *et al.*, 2001; Naeem, 2001; Otteson *et al.*, 2008). Similarly nitrogen fertilization also contributed in increasing tiller production up to an optimum level (Pandy *et al.*, 2001; Singh *et al.*, 2002; Islam *et al.*, 2002). Above optimum, the decrease in tillers might be due to the competition for space.

Spike length: Seed rate and nitrogen levels significantly affected spike length (Table 1). Maximum spike length (12.81 cm) was observed at seeding rate of 150 kg/ha and was at par with 175 kg/ha (12.60 cm), while

Table 1: Mean square values of different yield and yield components of wheat

SOV	df	Plant height (cm)	Effective tillers m^{-2}	Spike length (cm)	Spikelets $spike^{-1}$	Grains $spike^{-1}$	1000 grain weight (g)	Biological yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Harvest index (%)
Seeding rates	2	68.89*	37326.20*	2.22*	4.82ns	40.29*	40.24*	363605.36*	329975.02*	12.22*
Nitrogen levels	4	354.75*	2027.74*	21.03*	28.72*	112.74*	116.96*	3038859.00*	329975.02*	117.65*
S x N	8	3.22ns	56.81ns	0.351ns	0.656ns	9.26*	2.22ns	11306.86*	19041.83*	1.23*
Error	28	2.57	76.96	0.1851	1.75	3.71	2.81	4364.77	1798.12	0.125

Table 2: Effect of seeding rates and nitrogen levels on yield and yield components of wheat

Treatments (kg ha^{-1})	Plant height (cm)	Effective tillers m^{-2}	Spike length (cm)	Spikelets $spike^{-1}$	Grains $spike^{-1}$	1000 grain weight (g)	Biological yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Harvest index (%)
Individual mean comparison of seeding rates									
125	94.99b	404.40c	12.07b	14.13	42.13b	44.39b	8975c	3949c	43.83b
150	98.33a	464.60b	12.81a	15.20	45.27a	47.28a	9281a	4242a	45.48a
175	94.33b	503.40a	12.60a	14.33	44.53a	47.17a	9178b	4055b	44.02b
LSD (p<0.05)	1.198	6.561	0.321	0.322	1.440	1.253	49.415	31.717	0.264
Individual mean comparison of nitrogen fertilizer application									
0	85.92d	434.56d	10.19d	12.33c	38.44d	41.17d	8243e	3193e	38.74e
75	94.01c	452.00c	12.07c	13.78b	42.89c	44.61c	8915d	3864d	43.33d
100	98.72b	461.56b	13.00b	14.89b	45.89ab	47.61b	9512b	4477b	47.06b
125	102.18a	473.78a	14.36a	17.22a	47.67a	50.81a	9695a	4629a	47.72a
150	98.58b	465.44b	12.86b	14.56b	45.00b	47.19b	9360c	4248c	45.37c
LSD (p<0.05)	1.546	8.470	0.415	0.417	1.859	1.618	63.795	40.946	0.341

Table 3: Effect of seeding rates and nitrogen levels on yield and yield components of wheat

Seeding rates (kg ha^{-1})	Nitrogen levels (kg ha^{-1})	Plant height (cm)	Effective tillers $plant^{-1}$	Spikelets $spike^{-1}$	Spike length (cm)	Grains $spike^{-1}$	1000 grain weight (g)	Biological yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Harvest index
125	0	85.70	382.67	12.00	9.77	36.00j	39.02	8141m	3117m	38.29i
	75	94.23	399.67	13.33	11.60	41.00h	42.39	8729j	3724j	42.66f
	100	97.40	409.67	14.00	12.90	43.00g	45.01	9377f	4365e	46.55
	125	101.47	421.67	17.00	13.67	47.00bc	49.20	9441e	4425d	46.88c
	150	96.17	408.33	14.33	12.40	43.67fg	46.31	9189g	4114g	44.77e
150	0	87.87	434.67	13.33	10.50	39.00i	41.80	8319k	3213l	38.63h
	75	96.33	460.00	14.00	12.30	44.33efg	46.56	9090h	4066h	44.73e
	100	102.00	468.33	15.33	12.73	46.33cd	48.57	9644c	4633b	48.04b
	125	104.37	481.33	18.00	15.07	51.00a	52.26	9906a	4894a	49.41a
	150	101.07	478.67	15.33	13.47	45.67cde	47.19	9448e	4404d	46.61d
175	0	84.20	486.33	11.67	10.30	40.33hi	S3	8269l	3249k	39.29g
	75	91.47	496.33	14.00	12.30	43.33g	42.69	8925i	3802i	42.60f
	100	96.77	506.67	15.33	13.37	48.33b	44.89	9516d	4433d	46.59d
	125	100.70	518.33	16.67	14.33	45.00def	49.25	9739b	4566c	46.89c
	150	98.50	509.33	14.00	12.70	45.67cde	50.97	9441e	4225f	44.75e
LSD (p<0.05)	-	-	-	-	-	1.441	-	49.416	31.719	0.266

minimum spike length (12.07 cm) was recorded at seeding rate of 125 kg/ha (Table 2). Spike length was significantly affected by nitrogen fertilization (Table 1). Longer spikes were observed at nitrogen level of 125 kg/ha followed by 150 kg/ha and 100 kg/ha which were at par while shorter spikes were recorded at zero level of nitrogen (Table 2). Non significant interaction between seeding rate and nitrogen levels was found (Table 3). However more spike length was observed at seeding rate of 150 kg/ha at 125 kg/ha nitrogen level. These results are in agreement with those of Hussain *et al.* (2001) and Ahmad *et al.* (2000).They concluded that spike length of wheat was increased significantly with increasing nitrogen levels.

Number of spikelets/spike: Seeding rate did not affect number of spikelets/spike; however, nitrogen fertilization significantly affected spiklets/spike (Table 1). Maximum number of spikelets/spike was observed at nitrogen level of 125 kg/ha followed by 100 kg/ha, 150 kg/ha and 175 kg/ha (Table 2). Minimum number of spikelets/spike was recorded at zero level of nitrogen. The interaction of seeding rate and nitrogen levels were found non significant (Table 3). However greater number of spikelets per spike was observed at seeding rate of 150 kg/ha. Nitrogen application and seeding rate have significant affects on the number of spikelets/spike as reported by Khan *et al.* (2000), Naeem (2001) and Islam *et al.* (2002). However, contradictory results of seeding rates were reported by Khaliq *et al.* (1999). They stated that number of spikelets/spike was significantly increased with increasing seeding density.

Number of grains/spike: Grains/spike is also an important yield contributing parameter to the final grain yield of wheat crop. Number of grains/spike was statistically affected by seeding rate and nitrogen levels (Table 1). Maximum number of grains (45.27)/spike were observed at seeding rate of 150 kg/ha and was similar to 150 kg/ha while minimum number of grains (42.13)/spike were recorded at seeding rate of 125 kg/ha. More number of grains/spike were counted at nitrogen level of 125 kg/ha followed by 100 kg/ha and 150 kg/ha while least number of grains (38.44)/spike were recorded at zero level of nitrogen. The interaction of seeding rate and nitrogen levels were found significant (Table 1). Highest number of grains (51.00) / spike were found in seeding rate of 150 kg/ha with 125 kg/ha nitrogen level while lowest number of grains (36.00)/spike were counted in zero level of nitrogen at 125 kg/ha of seeding rate (Table 3). Increased number of grain/spike might be due to optimum crop stand with better nutrition. Better nutrition enhanced the source capacity to better fill the sink. Our result are in agreement with Naeem (2001) concluded that all cultivars differ significantly regarding Number of grains/spike. Maqsood *et al.* (2002) found that application of 150 kg N/ha gave the maximum number of grains/spike. Islam *et al.* (2002) found that plots of wheat crop fertilized with 170 kg N/ha had maximum grains per spike. Khan *et al.* (2000) found that all the seeding rates had significant effect on number of grains/spike.

1000-grains weight: Grain weight was statistically affected by seeding rate and nitrogen levels (Table 1). Heaviest grains (47.28 g) and (47.17 g) were observed at seeding rate of 150 kg/ha and 175 kg/ha respectively while lowest grains (44.39 g) weight was recorded at seeding rate of 125 kg/ha. Nitrogen fertilization also has pronounced effect on 1000-grain weight of wheat (Table 1). Maximum grain weights were observed at nitrogen level of 125 kg/ha followed by 100 kg/ha and 150 kg/ha (Table 2). Minimum grain weight (41.17 g) was recorded at zero level of nitrogen. The interaction of seeding rate and nitrogen levels was found non significant (Table 3). However more 1000-grain weight was observed at seeding rate of 175 kg/ha with 125 kg/ha nitrogen. Similar results were reported by Chandra *et al.* (1992). They observed that 1000-grain weight was enhanced by increasing nitrogen level from 120 kg N/ha to 150 kg N/ha. Awasthi and Bhan (1993) and Maqsood *et al.* (2002) concluded that 1000-grain weight significantly increased with increasing nitrogen levels.

Grain yield: Grain yield of wheat is the function of its unique yield component in response to nitrogen level and seeding rate for the yield of the crop. Grain yield is highly influenced by crop nutrition and planting distance. Seeding rate and nitrogen significantly affected grain yield of wheat (Table 1). Higher grain yield (4242.07 kg/ha) was calculated at seeding rate of 150 kg/ha while lower grain yield (3949.13 kg/ha) was recorded at seeding rate of 125 kg/ha. Application of nitrogen also affected grain yield (Table 1). Maximum grain yield (4626 kg/ha) was observed at nitrogen level of 125 kg/ha followed by 100 kg/ha (4477 kg/ha) while lowest grain yield (3193 kg/ha) was recorded at zero level of nitrogen. The interaction of seeding rate and nitrogen levels was found significant (Table 1). Highest grain yield (4894 kg/ha) was noted at seeding rate of 150 kg/ha1 with 125 kg/ha nitrogen fertilizer while lower grain yield (3117 kg/ha) was counted in zero level of nitrogen and 125 kg/ha of seeding rate (Table 3). Maximum grain yield might be attributed to the improvement in number of tillers, spike length, grain/spike and 1000 grain weight. Similar results were obtained by Pandy *et al.* (2001) and Singh *et al.* (2002). They reported that increasing nitrogen rates increased grain yield. Maqsood *et al.* (2002) found that application of 150 kg N/ha gave the highest grain yield. Islam *et al.* (2002) found that plots of wheat crop fertilized with 170 kg N/ha had maximum grain yield. Nitrogen fertilizer up to 150 kg/ha increased the grain yield, whereas higher levels of N fertilizer decreased both yields (Mojiri and Arzani, 2003). N application increased the grain yield by 9.6% in wheat and deficiency depressed the yield in cereals (Soylu *et al.*, 2005). In contrast Otteson *et al.* (2007) concluded that nitrogen level, nitrogen timing and seeding rate impose non-significant effect on grain yield.

Biological yield: Biological yield represent overall growth performance of the plant as well as the crop and is considered to be the essential yield parameter to get useful information about overall growth of the crop of wheat. Biological yield is highly inclined by crop nutrition and planting distance. Biological yield was statistically affected by seeding rate and nitrogen levels (Table 1). Highest biological yield (9281 kg/ha) was calculated at seeding rate of 150 kg/ha while lowest biological yield (8975 kg/ha) was recorded at seeding rate of 125 kg/ha and was statistically lower from seeding rate of 175 kg/ ha (9178 kg/ha; Table 2). Nitrogen fertilization also has prominent effect on biological yield of wheat (Table 1). Maximum biological yield (9596 kg/ha) was observed at nitrogen level of 125 kg/ha followed by 100 kg/ha (9512 kg/ha) while lowest grain yield (8243 kg/ha) was recorded at zero level of nitrogen (Table 2). The interaction of seeding rate and nitrogen levels were found significant (Table 1). Highest biological yield (9906 kg/ha) was found at seeding rate of 150 kg/ ha with 125 kg/ha nitrogen fertilizer while lowest biological yield (8141 kg/ha) was noted in zero level of nitrogen with 125 kg/ha of seeding rate (Table 3). Increased in biomass production might be attributed to the increased plant population due to higher seeding rate with better nitrogen application. These results are in agreement with Islam *et al.* (2002), Mojiri and Arzani (2003) and Soylu *et al.* (2005). Otteson *et al.* (2007) found that biological yield was increased by increasing nitrogen up to optimum levels. Nayyar *et al.* (1992) obtained the highest biological yield at higher seeding rate of 100 kg/ha.

Harvest index: The ability of a cultivar to convert the dry matter into economic yield is indicated by its harvest index. The higher the harvest index value, the greater the physiological potential of the crop for the converting dry matter to grain yield. Harvest index was statistically affected by seeding rate and nitrogen levels (Table 1). Highest harvest index (45.48) was calculated at seeding rate of 150 kg/ha while lowest Harvest index (43.83) was recorded at seeding rate of 125 kg/ha and was statistically lower than seeding rate of 175 kg/ha (Table 2). Nitrogen fertilization also has improved harvest index up to optimum level (Table 2). Maximum harvest index (47.72) was observed at nitrogen level of 125 kg/ha followed by 100 kg/ha (47.06) while minimum harvest index (38.74) was recorded at zero level of nitrogen. The interaction of seeding rate and nitrogen levels was found significant (Table 1). Maximum harvest index (49.41) was found in seeding rate of 150 kg/ha with 125 kg/ha nitrogen, while, minimum harvest index (38.29) was observed in zero level of nitrogen with 125 kg/ha of seeding rate. Increase in nitrogen level increased harvest index (Singh *et al.*, 2002). Islam *et al.* (2002) found that plots of wheat crop fertilized with 170 kg N/ha had maximum harvest index.

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