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Nitrogen fertilizer level optimization for recently developed wheat (*Triticum aestivum*) cultivars

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The influence of nitrogen rates on the development and yield of newly generated wheat (*Triticum aestivum* L.) varieties was tested in a field experiment. The seed rate for the crop was 125 kg ha^{-1}. Five nitrogen rates were investigated on the wheat types Sehar-2006, Punjab-2011, and Millat-2011: 0, 50, 100, 150, and 200 kg ha^{-1}. Half of the nitrogen and total phosphorus doses (75 kg ha^{-1}) were applied at planting, with the other half nitrogen applied at the first watering. The yield, as well as the components of the yield, were recorded. At 100 kg N ha^{-1}, all three types, Sehar-2006, Punjab-2011, and Millat-2011, performed well. In 2011, Punjab (4.49 t ha^{-1}) produced the most, followed by Millat (3.72 t ha^{-1}) and Sehar (3.72 t ha^{-1}). (3.53 tons per hectare). Punjab-2011 has the highest grain protein content at 100 kg N ha^{-1} (12.56 percent).

Keywords: Grain yield; nitrogen rate; protein contents; varieties; wheat

INTRODUCTION

Wheat (Triticum aestivum L.) is a typical food in Pakistan, where it is consumed by the majority of the people (Agu, Bringhurst et al. 2006). It contributes to 12.5 percent of agricultural value-added and 2.6 percent of GDP. Wheat is a good source of carbs and protein for humans and animals (Gholamin and Khayatnezhad 2020, Bi, Dan et al. 2021, Li, Mu et al. 2021). Its straw components are used to produce animal feed and paper (Khayatnezhad and Gholamin 2020, Si, Gao et al. 2020). Pakistan's economy and well-being are dependent on a solid wheat harvest due to its widespread and diversified usage in everyday life. China, Mexico, Australia, France, Egypt, Germany, and the United Kingdom produced average yields of 3729, 4404, 4500, 6487, 6251, 7282, and 7700 kilos per hectare, respectively (Xu, Ouyang et al. 2021, Zhu, Liu et al. 2021). The average yield falls well short of modern cultivars' genetic potential (Ahmad, Yousaf et al. 2000). Low wheat yields in Pakistan are due to nutrient inadequacy in the soil, delayed planting, selection of low-potential cultivars, less effective and traditional sowing procedures, irrigation water scarcity, and inadequate weed control measures (Chowdary, Rao et al. 2004). Because it stimulates plant vegetative development, nitrogen is critical in increasing yield.

Nitrogen increases leaf area, which improves PAR capture and use in photosynthetically active radiation (PAR) (Gholamin and Khayatnezhad 2020, Ma, Ji et al. 2021, Zheng, Zhao et al. 2021). Nitrogen has a crucial role in plant metabolism and cereal grain production. Chlorophyll, the main absorber of light energy during photosynthesis, needs the presence of nitrogen (Khayatnezhad and Gholamin 2020, Sun and Khayatnezhad 2021). Nitrogen availability influences carbohydrate consumption and is linked to high photosynthetic activity, rapid vegetative growth, and a dark green hue (Constable 2021). Treatments of up to 120 kg ha^{-1} nitrogen have been reported to boost wheat grain production and protein content. The use of more nitrogen fertilizer to raise cereal crop protein content has recently gained a lot of attention (Khayatnezhad and Gholamin 2021, Tao, Cui et al. 2021). The physical qualities of grain, such as hardness and virtue, are affected by nitrogen fertilizer (Hameed, Shah et al. 2003). It also impacts the protein and wet gluten content of flour (Hussain, Khaliq et al. 2013, Khayatnezhad and Gholamin 2021). Plant stress and nitrogen management may influence the deposition of gliadin and glutenin proteins in the kernel (Ma, Khayatnezhad et al. 2021, Zhang, Khayatnezhad et al. 2021, Zhu, Saadati et al. 2021). Khaliq et al. (2013) observed that as grain filling advances, the relative concentration of gliadin, initially deposited in the kernel, falls. Lowering N stress may increase the close quantity of gliadin in the seed (Khayatnezhad and Nasehi 2021).

Nitrogen application early in the growing season, when moisture availability is greatest, causes profuse tillering, high dry matter production, and a large lush green transpiring surface, which can cause early soil moisture depletion, reducing nitrogen response and, in some cases, reducing ultimate yield (Gholamin and Khayatnezhad 2020, Guo, She et al. 2021, Huang, Wang et al. 2021). Increased cropping intensity and the introduction of high-yielding cultivars have resulted in significant nitrogen loss, and crops have responded well to nitrogen addition in the soil (Jia, Khayatnezhad et al. 2020, Ren and Khayatnezhad 2021). Several agricultural strategies may help increase the efficiency of nitrogen utilization (Nasim, Ahmad et al. 2012). The groundwater system may readily absorb nitrate since it is one of the most water-soluble anions (Rachon, Szwed-Urbas et al. 2002, RAHMAN 2015, Wang, Shang et al. 2021, Yin, Khayatnezhad et al. 2021). It is hazardous to people's health, particularly babies, resulting in "blue baby syndrome" (Sun, Lin et al. 2021). The nitrogen utilization efficiency of wheat and other cereal crops has improved as the cost of generating and supplying nitrogen fertilizer has grown. As a result, proper nitrogen management is essential for economic wheat production and long-term environmental sustainability (Peng, Khayatnezhad et al. 2021). Cultivars have a significant influence in boosting yield per square foot. Various wheat cultivars provide different results depending on the environment (Ali et al., 2014). Cultivars varied substantially in terms of the number of viable tillers per m^{-2}, spike length, 1000-grain weight, and straw yield (Karasakal, Khayatnezhad et al. 2020). Nitrogen absorption rate and nitrogen utilization efficiency are higher in innovative and high-potential cultivars. Wheat types showed varying grain yields and components at various nitrogen levels (Hou, Li et al. 2021). The current research focused on the development and yield response of newly created wheat varieties under diverse nitrogen rates due to the relevance of nitrogen and varietal behavior for wheat production.

MATERIALS AND METHODS

During Rabi 2011-12, an experiment was conducted at the University of Agriculture, Karaj, Iran, to evaluate the performance of newly created wheat varieties at varying nitrogen levels. Soil samples were collected to a depth of 30 cm before sowing the crop for physio-chemical analysis. Three wheat cultivars were employed in a factorial design with five nitrogen levels (0, 50, 100, 150, and 200 kg ha^{-1}) and three replications (Sehar-2006, Punjab-2011, and Millat-2011). The crop was planted on November 20, 2011, with a net plot size of 1.8 m x 5 m and a row-to-row spacing of 22.5 cm and a seed rate of 125 kg ha-1 and a seed rate of 125 kg ha^{-1}, and a seed rate of 125 kg ha^{-1} As per treatment, the necessary phosphorous dose (75 kg ha^{-1}) was delivered as a single super phosphate (SSP) at the time of sowing, while nitrogen was provided in two splits, half at the time of sowing and a half during the first irrigation. All other agronomic and cultural activities were kept the same for all treatments. Fisher's analysis of variance (Warraich, Basra et al. 2002) was used to evaluate the data. The means of the treatments were compared using the least significant difference (LSD) test at the 5% probability level. The protein content of wheat grains was measured using Gunning and Hibbard's approach of sulphuric acid digestion followed by NH3 distillation in boric acid using the Kjeldhal apparatus (Wheaton and Muller 2000).

RESULTS AND DISCUSSION

Fertilizer dosages and cultivars had a substantial impact on the total number of tillers per unit area, as shown in Table 1. The interaction between two components, on the other hand, did not reach a statistically significant level (Table 2). Treatment N3, which applied 150 kg N ha^{-1}, had the highest total number of tillers (529.5 m^{-2}) and the lowest whole number of tillers (479.5 m-2) (350.7 m-2). Punjab-2011 generated the total tillers (464.3 m^{-2}) and was statistically different from the other two kinds, Sehar-2006 and Millat-2011, which produced 447.8 and 446.7 tillers m-2, respectively. Increased fertilizer levels increased the number of tillers per plant, according to Zamir (2010), with a nitrogen dosage of 160 kg N ha^{-1} resulting in the wheat variety with the most tillers per unit area (Fakhar-e-Sarhad).

Cultivars, as well as nitrogen levels, have a substantial impact on plant height. However, there was no evidence of a significant interaction between the two factors (Table 1). (Refer to Table 2) In terms of nitrogenous fertilizer rates, all treated plots had considerably greater plant heights than the control plots. The 200 kg ha^{-1} treatment produced the tallest plants (110.5 cm), whereas the control plots produced the shortest plants (92.3 cm). Even though Sehar-2006 and Millat-2011 were statistically equal, Punjab-2011 made the tallest plants of the three kinds (107.2 cm).

With 100 kg N ha^{-1}, which was statistically comparable to 150 kg ha^{-1}, which produced 15.2 spikelets per spike, the most spikelets per spike (15.6) were achieved (Table 1). Different sorts of nitrogen rates substantially impacted the number of spikelets per spike, albeit the interaction was not significant (Table 2). Punjab-2011 had the highest number of spikelets per spike (16.5), outnumbering the other two varieties. Punjab-2011, compared to Millat-2011 and Sehar-2006, may have a better genetic potential for creating spikelets per spike. Previous research has shown genotypic differences in wheat types regarding the number of spikelets per spike.

In 100 kg ha^{-1}, the largest number of grains per spike (61.6) was recorded, whereas the lowest number was found in the control (45.3). The quantity of nitrogen fertilizer used has a significant impact on the number of grains produced per spike. Although statistically equal to Sehar-2006 wheat variety (Table 1), Punjab-2011 wheat variety produced significantly more grains per spike (59.1) than Millat-2011 wheat variety (Table 1), Punjab-2011 wheat variety produced significantly more grains per spike (59.1) than Millat-2011 wheat variety (Table 1). (54.2). The variation in grain output per spike might be explained by differences in genetic potential among these three wheat varieties. Depending on nitrogen levels and wheat varietals, the number of grains per spike varies dramatically.

Wheat grain production is heavily influenced by grain weight, which is an essential yield component. While there was no significant interaction between varieties and nitrogenous fertilizer rates, differing nitrogen levels and varieties resulted in substantial changes in 1000-grain weight (Table 1). (See Table 2) The 1000-grain weight in 150 kg ha^{-1} was the greatest (42.1 g), which was statistically similar to the 41.5 g 1000-grain weight in 100 kg ha-1. Punjab-2011 was the variety with the greatest 1000-grain weight (41.9 g), followed by Millat-2011 (40.3 g), and Sehar-2006 (40.3 g) (36.8 g). Nitrogen levels were shown to have a considerable impact on wheat grain weight in a previous research(Cheng, Hong et al. 2021, Gholamin and Khayatnezhad 2021).

The total biomass generated by a crop over a certain area is referred to as biological yield. Production is influenced by the number of tillers per unit area, plant height, number of grains per spike, and grain weight per 1000 grains. Table 1 shows how biological production varies greatly depending on cultivar and nitrogen rate, as well as how they interact (Table 2). When Punjab-2011 was fertilized with 100 or 150 kg N ha-1, the biological yield was much higher (14.3 t ha^{-1}) than when other treatment combinations were used. Sehar-2006 had the lowest biological yield at control (8.6 t ha^{-1}), which was statistically equivalent to Millat-2011 at control. Wheat biological production is boosted by increased nitrogen levels of up to 150 kg ha^{-1} (Karasakal, Khayatnezhad et al. 2020). Due to a larger number of tillers per unit area, Punjab-2011 had a better biological yield than Sehar-2006 and Millat-2011 (Table 1).

Table 1 shows how grain yield was impacted by various wheat cultivars and nitrogen fertilizer rates. Varietal reaction to different nitrogen treatment rates was changed according to interaction values (Table 2). With 150 kg N ha^{-1}, Sehar-2006 generated a high grain yield (4.2 t ha^{-1}) that was similar to the yield achieved with 100 kg N ha^{-1}. Punjab-2011 had the highest grain yield (5.2 t ha^{-1}) with 100 kg N ha^{-1}, followed by 150 kg N ha-1 (5.2 t ha^{-1}) (Table 1). With 150 kg N ha^{-1}, Millat-2011 produced the maximum grain yield, which was substantially higher than all other nitrogen treatment rates. The effect of nitrogenous fertilizer rate on grain yield in wheat cultivars is linear (Karasakal, Khayatnezhad et al. 2020). Grain output improved when nitrogen fertilizer rates were raised to 150 kg ha^{-1}. Different nitrogenous fertilizer rates and wheat cultivars had a substantial influence, according to Table 1. Between the two components, there was also a considerable interaction (Table 2).

Table 1: Mean comparison of yield and yield components of wheat as affected by nitrogen and cultivar

Wheat cultivar	No. of Tillers (m^{-2})	Plant Height (cm)	No. of spikelet per spike	No. of Grains Per spike	1000-Grain wt.(g)	Biological yield (t ha^{-1})	Grain Yield (t ha^{-1})	Harvest index	Protein contents (%)
Sehar-2006	447.8b	101.8b	13.8c	54.8b	36.8c	11.3b	3.5b	0.31b	10.1b
Punjab-2011	464.3a	107.2a	16.3a	59.1a	41.9a	12.7a	4.3a	0.33a	11.3a
Millat-2011	446.7b	100.7b	15.0b	54.2b	40.3b	10.5c	3.7b	0.34a	10.9a
LSD	12.80	2.07	2.10	2.10	1.53	0.27	0.15	0.13	0.66
Nitrogen level (N)									
0 kg ha^{-1}	350.7d	92.3e	14.8bc	45.3d	38.3b	8.9c	2.8d	0.31b	8.2d
50 kg ha^{-1}	395.1c	101.4d	14.9bc	56.5c	38.6b	11.1b	3.8b	0.34a	10.0c
100 kg ha^{-1}	501.2b	104.1c	15.6a	61.6a	41.5a	12.9a	4.5a	0.34a	11.3b
150 kg ha^{-1}	529.6a	107.7b	15.2ab	59.7ab	42.1a	13.2a	4.6a	0.34a	12.1ab
200 kg ha^{-1}	487.6b	110.5a	14.7c	57.1bc	37.9b	11.4b	3.5c	0.31b	12.3a
LSD	16.53	2.67	0.45	2.79	1.98	0.61	0.19	0.17	0.85
Means with the same letter in each column are not significantly different at probability level of 5%.									

Table 2: Interaction effects of nitrogen and variety on yield and yield components

Wheat cultivar	No. of Tillers (m^{-2})	Plant height (cm)	No. of spikelet per spike	No. of Grains per spike	1000-Grain (g)	Yield (t ha^{-1})	Grain yield (t ha^{-1})	HI	Protein Contents (%)
0 kg ha^{-1}×Sehar-2006	353.0	87.9	13.4	44.3	34.3	8.6h	2.7i	0.31e	7.7
50 kg ha^{-1}× Sehar-2006	396.3	100.1	13.8	54.0	34.4	10.2f	3.2gh	0.32cde	9.3
100 kg ha^{-1} ×Sehar-2006	491.6	104.2	14.3	59.5	39.0	12.8bc	4.1de	0.32de	10.8
150 kg ha^{-1} ×Sehar-2006	521.6	105.7	13.9	58.8	41.7	13.3b	4.2d	0.31e	11.5
200 kg ha^{-1} ×Sehar-2006	476.6	111.1	13.9	57.3	34.8	11.6e	3.4fg	0.29e	11.5
0 kg ha^{-1}× Punjab-2011	354.6	100.2	16.0	47.9	40.3	9.5g	2.9hi	0.30e	8.9
50 kg ha^{-1}× Punjab-2011	406.3	104.9	16.2	59.7	40.3	13.3b	4.8bc	0.37ab	10.8
100 kg ha^{-1}× Punjab-2011	516.3	107.1	16.9	64.1	43.1	14.3a	5.2a	0.38ab	11.7
150 kg ha^{-1}× Punjab-2011	541.6	112.5	16.8	63.8	44.1	14.3a	5.0ab	0.35b	12.4
200 kg ha^{-1}× Punjab-2011	502.6	111.4	16.7	59.9	40.9	12.4cd	3.7ef	0.30e	12.8
0 kg ha^{-1}× Millat-2011	344.3	89.0	14.9	43.6	40.4	8.6h	2.7i	0.30e	8.0
50 kg ha^{-1}× Millat-2011	382.7	99.3	14.6	55.9	40.1	9.9fg	3.5fg	0.34bc	10.0
100 kg ha^{-1}× Millat-2011	495.7	101.0	15.6	61.2	42.5	11.7e	4.1d	0.35b	11.6
150 kg ha^{-1}× Millat-2011	525.3	105.0	14.9	56.4	40.6	12.1de	4.6c	0.38a	12.4
200 kg ha^{-1}× Millat-2011	483.3	109.2	15.2	54.0	38.1	10.0fg	3.4fg	0.34bcd	12.7
LSD	NS	NS	NS	NS	NS	0.61	0.34	0.30	NS

Means with the same letter in each column are not significantly different at probability level of 5%.

At 150 kg ha-1, Millat-2011 had the highest harvest index (38.4%), although it was statistically equal to Punjab-2011 at 150 kg ha^{-1} and Punjab-2011 at 100 kg ha^{-1}, both of which had harvest indices of 36.8% and 36.7 percent, respectively. Wheat with 150 kg N ha^{-1} has the greatest harvest index value, according to research (Peng, Khayatnezhad et al. 2021). Proteins are enzymes that work inside the body of a plant. Proteins are therefore required for plant development and a range of yield-related metrics in cereals. Table 1 shows the influence of nitrogen levels on grain protein content (percent) in a variety of wheat cultivars. Grain protein content (percent) varied substantially across wheat types and nitrogen fertilizer rates, despite the fact that the interaction between the two components was not significant. When it came to nitrogen application rates, 200 kg N ha^{-1} yielded the greatest percentage of grain protein (12.3%), while the control yielded the lowest (8.2 percent). Punjab-2011 had the greatest grain protein level (11.3%) of the three wheat varieties, which was statistically similar to Millat-2011 (10.9 percent). In Sehar-2006, the lowest grain protein content (10.1%) was observed. When nitrogen levels were changed, grain protein content (percent) differed dramatically amongst wheat varieties (Khaliq, Gondal et al. 2013).

CONCLUSION

According to the findings, under the climatic circumstances of Faisalabad (Pakistan), wheat variety Punjab-2011 may be farmed with nitrogen at a rate of 100 kg ha^{-1} for the best economic return. To optimize nitrogen fertilizer dosage in varied climates, future research should incorporate a broad range of nitrogen levels and a large number of genotypes.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Mani Alizadeh conducted, planned, Analyzed the data, wrote manuscript and interpreted the results and involved in manuscript preparation. All authors read and approved the final version.

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