Original Research Article

Effect of nitrogen and phosphorus fertilizer doses on agro morphological parameters of wheat varieties in vertisol region in India

ABSTRACT

Wheat is the most important food grain, with more than a third of the world's population eating it as a staple diet for the optimum use of different nutrients. A field experiment was carried out at ICAR-IISS Bhopal to identify different wheat varieties that provide the highest yield under nutrient stress conditions. In this experiment, we studied the different morphological parameters in nine wheat varieties, i.e., plant height, plant dry weight, biological yield, and grain yield. With three replications, the experiment was set up in a split-plot design. There were 36 treatments in total, including three nitrogen levels and three P levels with nine genotypes, in each replication. In each replication, all of the treatments were split separately. T1 was the control treatment, and T2 was the optimum dose treatment. T3 was 50% nitrogen with a full phosphorus dose, and T4 was 50% phosphorus with 100% nitrogen doses. In sub-optimal doses of N and P (T_3 and T_4), T_3 produced a higher biomass yield than T_4, averaging all the selected nine varieties of wheat, whereas T_4 had a higher grain yield than T3. The study's current findings, which showed that higher nitrogen fertilizer doses enhanced leaf area, plant dry weight, maximum biomass, and grain production, were consistent with this. Because nitrogen affects photosynthesis, the amount of photo assimilates the plant produces, the partitioning of dry matter, and organ development, it may have an impact on seed output along with phosphorus.

Keywords: Wheat, Staple diet, Soil fertility, Morphological parameters, Varieties Biological yield.

1. INTRODUCTION

One of the most critical elements for crop productivity is nitrogen (N). Increased growth and biomass yields arise from the application of nitrogen fertilizer. It has a direct impact on the protein and amino acid content and, as a result, the nutritional quality of the economic produce. (Maheswari *et. al.,* [1] 2017).

Phosphorus (P) is one of the most important nutrients for plant growth and survival. It is essential for cellular bioenergetics and metabolic pathways within the plant body. The primary function of mineral fertilizers is to increase crop yields, but the biggest impediment to realising known crop potential is the low use of fertilizers, notably P and N.(Irfan *et al.,* 2018).

Kaur *et al.,* (2015) conducted a two-year field experiment to screen twelve wheat genotypes for optimal nitrogen usage efficiency under four levels of nitrogen management (recommended dose of nitrogen; RDN, RDN-50 percent, RDN-25 percent, and RDN+25 percent). The result indicated that plant height, tiller number, spikelet number, grain yield, thousand grain weight, and biomass all increased with an increase in the nitrogen dose).

Patel *et al.,* (2012) observed that In a wheat field experiment with three nitrogen levels (0, 60, and 120 kg N/ha), the highest nitrogen fertilised plot (120 kg N/ha) had the highest values for growth attributes such as plant height and number of leaves or plants and yield attributes such as number of grains or spikes, spike length grain, and straw yield. Among the four wheat genotypes evaluated, the nitrogen consumption efficiency (agronomic efficiency) of two genotypes at 60 kg nitrogen application was significantly higher than the other genotypes at 120 kg N/ha. In a study, the effects of three N, P, and K levels (35-25-25, 70-50-50, and 105-75-75 kg ha^{-1}) on the growth, yield, and quality of three wheat types were investigated by (Salim, N., & Raza, A. (2020). Plant height, number of viable tillers, 1000-grain weight, grain yield, and grain protein content of wheat were all altered by different NPK levels. The application of 105-75-75 kg NPK ha^{-1} resulted in the maximum grain production (4.99 t ha^{-1}).

The effects of various nitrogen fertilization levels (0, 60, 120, and 180 kg/ ha N) on the agronomic performance of six wheat (*Triticum aestivum* L.) cultivars were investigated by Benin *et al.,* 2012) the result indicated that in the cultivars tested, there was genetic diversity in response to nitrogen fertilization. Higher nitrogen fertilizer levels were linked to better yield component performance and a more suited water regime resulted with the greatest yield gains.

Tahir *et al.,* (2020) studied 12 bread wheat cultivars released for a heat-stressed environment on yield performance for two seasons at four nitrogen levels (0 (N_0), 43 (N_{43}), 86 (N_{86}), and 129 (N_{129}) kg/ha). Increasing N levels from N_0 to N_{43}, N_{86}, and N_{129} resulted in yield increases of 4-45 percent, 13–69 percent, and 34–87 percent at N_{43}, N_{86}, and N_{129}, respectively, when averaged across the seasons. These increases in crop yield were linked to increases in biomass growth (r = 0.86).

The efficiency of wheat crops that utilizes nitrogen effectively is determined by genetic and environmental factors. Kraisig *et al.,* (2021) evaluated the efficiency of nitrogen consumption by wheat genotypes as a measure of biomass, productivity, and grain quality parameters. The result indicated that there were reported genetic differences in nitrogen usage efficiency, productivity (yield and biomass), and wheat quality. With an increase in N-fertilizer, wheat crop production and biomass daily $rate^{-1}$ are affected significantly (Brezolin *et al.,* 2016).

Patel *et al.,* 2012) observed that in a wheat field experiment under three nitrogen levels (0, 60, and 120 kg N/ha) the higher values for growth attributes such as plant height and the number of leaves/plants; yield attributes such as the number of grains/spikes, spike length grain and straw yield were reported in the highest nitrogen fertilized plot (120 kg N/ha). Among the four wheat genotypes evaluated, two genotypes' nitrogen consumption efficiency (agronomic efficiency) at 60 kg nitrogen application was significantly higher than the other genotypes at 120 kg N/ha. In a study, the effects of three N, P, and K levels (35-25-25, 70-50-50, and 105-75-75 kg ha^{-1}) on the growth, yield, and quality of three wheat types were investigated by REHIM *et al.*,(2020) Plant height, the number of viable tillers, 1000-grain weight, grain yield, and grain protein content of wheat were all altered by different NPK levels. The application of 105-75-75 kg NPK ha^{-1} resulted in maximum grain production (4.99 t ha^{-1}).

The effects of various nitrogen fertilization levels (0, 60, 120, and 180 kg/ ha N) on the agronomic performance of six wheat (*Triticum aestivum* L.) cultivars were investigated by Benin *et al.*,(2012) the result indicated that in the cultivars tested, there was genetic diversity in response to nitrogen fertilization. Higher nitrogen fertilizer levels were linked to better yield component performance and a more suited water regime resulted in the greatest yield gains.

2. MATERIAL AND METHODS

The field experiment was conducted during the *rabi* season of 2020-21 at the research farm, ICAR-IISS, Bhopal and Madhya Pradesh. It comes under a semi-arid and sub-tropical zone and is characterized by hot summer and cold winter. Bhopal comes in Vindhyan Plateau Agro-climatic Zone. Mean annual precipitation is about 1100 mm, most of which is received during the monsoon period of July to September. The average maximum temperature during summer is 35-40°C, while the average minimum temperature during winter is 2-9°C.

Table 1 Weather data

	November	December	January	February	March	April	May
Temperature °C	22.4 °C	18.8 °C	20.0°C	21.1 °C	26 °C	26 °C	31.3 °C
Precipitation / Rainfall (mm)	303.8	254	203.2	304.8	228.6	228.6	101.6
Humidity (%)	0.47	0.5	0.5	0.42	0.29	0.29	0.21
Rainy days (d)	1	1	1	1	1	1	1
Avg. Sun hours (hours)	9.7	9.4	9.3	10	10.8	10.8	11.4

The wheat types were manually planted in lined furrows at a rate of 100 kg/ha on November 25, 2020, about 3 cm deep, with a row to row distance of 22.5 cm and a plant to plant distance of 5 cm

Nine varieties of wheat (*T. aestivum and T. durum*) crop were selected and grown as test crops in the current investigation adopting a split-plot design replicated thrice with nutrient dose as the main plot and varieties as subplot treatment there are 36 plots in a block (9 variety x 4 fertilizer N and P treatments). The area of each plot is 2m x 2m.

In all treatments except control, full-recommended doses of P and K fertilizers @ 60 kg P_2O_5 & 40 kg K_2O per acre were treated as a basal in SSP and MOP, respectively. N, P, and K were not included in the control plots (T_1). Normal dose treatment (T_2) received the authorized amount of N (120 kg ha-1) and P (60 kg/ha) while T_3 received half of the prescribed quantity of N (60 kg/ha) and a full dose of P (60 kg/ha). The T_4 treatment received the full dose of N and half dose of P fertilizers. 50 percent of the applied N is provided as basal, while the remaining N was top-dressed in equal splits at 25 and 45 DAS, respectively. The wheat crops were cultivated following standard agronomic practices and five irrigations (5 cm) and one manual weeding at 30 DAS was done.

The leaf area of plant samples was measured with the LICOR Leaf area meter (model 1100) and expressed in cm^2. Leaf area was assessed by choosing three plants at random in each treatment plot at 50, 65 and 85 DAS.

Plant height was taken at the physiological maturity stage of the crop in each replication comprising 5 plants and it was expressed in cm. Plant samples were collected from the treated plots and control plots. The whole plant was divided into above-ground biomass of the samples were dried at 65°C in an oven for 72 hrs or till constant weight. The dry weight of the plant sample was expressed in grams. Plant samples were collected from the treated plots and control plots. The whole plant was divided into above ground biomass of the samples were dried at 65°C in oven for 72 hrs or till constant weight. The dry weight of plant sample was expressed in gram.

The crop was harvested after it reached maturity, when the foliage had faded and the ears had assumed a yellowish hue. To eliminate the border impact, one border row from both sides and 30 cm from either end of each plot were collected. The remaining experimental plots were harvested with sickles, with ears detached and plant biomass wrapped into bundles. Each treatment's plant biomass (kg/ha), grain yield (kg/ha), and straw yield (kg/ha) were measured individually and weighed.

3. RESULTS AND DISCUSSION

The crop was harvested after it reached maturity, when the foliage had faded and the ears had assumed a yellowish hue. To eliminate the border impact, one border row from both sides and 30 cm from either end of each plot were collected. The remaining experimental plots were harvested with sickles, with ears detached and plant biomass wrapped into bundles. Each treatment's plant biomass (kg/ha), grain yield (kg/ha), and straw yield (kg/ha) were measured individually and weighed.

There was a strong influence from the three nitrogen and three phosphorus dosages. Plant height increased as the nitrogen level increased from zero to 120 kg/ha. When the nitrogen dose was 120 kg/ha, the maximum plant height (91 and 90 cm) was recorded, whereas the minimum plant height (65 cm) was reported in the control. The average plant height for the nine cultivars over the nitrogen dosages revealed that HI1544 had the highest plant height (87.63 cm) and HI8663 had the lowest plant height (71.38 cm). It was discovered that there was a considerable relationship between nitrogen, phosphorus, and cultivars. However, when the nitrogen dose was 120 kg/ha and the P dose was 30 kg, GW366 had the highest plant height (91 cm), but HI8737 had the lowest plant height (65 cm) with 0 kg/ha N and P fertilizers..

There were significant differences in the number of days achieving 50% flowering among varieties of wheat and fertilizer treatments. The number of days required to get 50% flowering was the lowest in HI8663 (62.5 days) and the highest in GW366 (80 days) (Table 2). The control plots had the most days to 50% flowering, followed by the reduced phosphatic fertilizer dose treatment, the reduced nitrogen fertilizer dose treatment, and the lowest in the 100% NP dose treatment. In this study, early flowering was observed with nitrogen fertilization, whereas it was delayed by a few days in the control conditions. The control conditions in the current study might have induced a nitrogen deficit, causing a delay in leaf development and leading to a delay in flowering by a few days. Several studies have shown that N deficiency/starvation causes delayed flowering in Arabidopsis.(Ata-Ul-Karim *et al.,*2016).Lin *et al.,* (2017) proposed that Arabidopsis has a Nitrogen regulated U-shaped flowering response. To see if this reaction can be extended to other plants and crops, a wide range of N concentrations must be explored systematically with a variety of species.

There were significant variations in days to maturity observed in terms of varieties of wheat and fertilizer treatments. Selected varieties matured between 100.5 (HI8663) and 135 days (Narmada14) among the nutrient treatments (Table 2). The varieties took a longer time to mature in control plots, followed by, reduced nitrogen fertilizer treatment, reduced phosphatic fertilizer treatment, and normal NP treatment. In a full dose of N and P treatment, the highest number of days taken for maturity was found in Narmada14 (125 days), and the lowest number of maturity days was found in HI8663 (100.5 days).

Wheat varieties and NP treatments had a significant effect on the leaf area of wheat at 50 DAS (Table 2). Leaf area was found between 122.18 (GW366) and 191.67 cm^2/per plant (NARMADA14) among all the treatments (Table 2). The mean leaf area of the wheat plant was higher in the 100% NP treatment (T_2) than in the reduced phosphatic fertilizer dose treatment (T_4) and the reduced nitrogen fertilizer dose treatment (T_3), and the lowest was in control plots. In T_2, the highest leaf area was recorded in Narmada14 (191.67 cm^2/per plant), and the lowest leaf area was found in HI1531 (162.53 cm^2/per plant). The highest leaf area at every stage of sampling was obtained in T_2 (100%NPK), and the lowest was in T_1 (control). There was little difference between 50 and 65 DAS, but it was lowest in 85 DAS. Amongst the varieties, the leaf area of Narmada 14 was the highest at 50 DAS and 85 DAS, whereas HI1531 recorded the highest leaf area at 65 DAS (Table 4). The lowest leaf area was recorded in GW 366 at 50 DAS; however, it was HI 8663 and HI 1531 at 65 and 85 DAS, respectively. Different nitrogen and phosphorus application doses resulted in significant differences in the leaf area (Table 2). At all growth stages of measurements, the normal dose treatment produced the highest leaf area in NARMADA 14 (191.67 cm^2) and Lok1 (182.97 cm2), while the treatment with no nitrogen or phosphorus (T_1) produced the lowest leaf area (GW 366 and HI1531). Nitrogen enrichment has been shown in numerous studies to enhance leaf area, flag leaf area, and plant development (Khursheed & Mohammed,2015).

Table 2 shows the effects of various nutrient treatments on total biomass yield and grain yield of nine wheat varieties. There were significant differences in plant biomass observed between varieties of wheat and fertilizer treatments (Table 2). Among all the treatments, the range of plant biomass was found to be between 5101.50 kg/ha (HI8663) and 10377.25 kg/ha (NARMADA14). The mean plant biomass was higher in the normal dose treatment, followed by, reduced phosphatic fertilizer dose treatment, the reduced nitrogen fertilizer dose treatment, and lower in the control plots. The highest plant biomass was found in NARMADA14 (10377.25 kg/ha) among the varieties grown in a full dose of N and P treatment, and the lowest plant biomass was found in HI8737 (8050.25 kg/ha). Among the varieties grown in a half dose of N fertilizer treatment, the highest plant biomass was observed in LOK1 (8781.25 kg/ha), followed by GW366 (8751.25 kg/ha), and among the varieties grown in a half dose of P, the highest plant biomass was found in NARMADA14 (9670.25 kg/ha), followed by HI1563

(9657.75 kg/ha). Total biomass yield is the total dry matter generated by a plant as a result of photosynthesis and nutrient uptake after accounting for losses during respiration (Shah, 1994). The selected nine wheat cultivars have shown considerable variations in biological yield (t/ha). There was a lot of interaction between the nine cultivars and the four levels of nutrients (nitrogen and phosphorus treatments). As the amount of nitrogen and phosphorus application was increased from the control level to 60 kg/ha and 120 kg/ha, the biological yield increased. Normal dose treatment yielded the highest biological output (10.37 t/ha).

Table 2 Results of different wheat varieties

Wheat varieties	Dry matter			Days to 50% flowering	Days to maturity	Leaf area (cm^2)			Plant Biomass kg/ha.	Grain yield kg/ha.
	50 DAS	65 DAS	85 DAS			50 DAS	65 DAS	85 DAS		
	Mean A	Mean A	Mean A	Mean A	Mean A	Mean A	Mean A	Mean A	Mean A	Mean A
HI8663	71.38	1.55	1.51	1.46	66.25	105.00	163.20	149.40	154.10	6345.81
HI8737	71.75	1.52	1.58	1.52	67.88	107.75	160.40	152.50	157.40	7754.31
HI8713	83.00	1.98	1.76	1.65	68.88	119.38	166.40	154.80	152.00	8409.38
HI1563,	78.88	1.48	1.33	1.23	70.75	116.63	168.40	157.30	148.60	8281.22
HI1544	87.63	1.67	1.64	1.50	67.13	116.75	153.80	165.10	144.50	8151.13
HI1531	79.63	1.48	1.49	1.33	71.75	125.25	146.50	171.10	136.80	7962.24
GW366	87.13	1.52	1.48	1.33	76.38	118.13	146.40	161.10	139.40	8605.75
LOK1	84.63	2.22	2.08	2.04	74.75	124.50	172.00	164.80	158.30	8738.28
NARMADA14	83.75	2.85	2.54	2.35	67.38	128.13	182.20	160.50	169.40	9109.13
Mean B	80.86	1.81	1.71	1.60	70.13	117.95	162.14	159.62	151.17	8150.81
Factors	**C.D.**									
Factor(A)	0.37	0.19	0.13	0.06	1.85	1.51	4.11	11.19	5.72	182.07
Factor(B)	3.05	0.10	0.16	0.06	0.99	1.79	4.45	9.34	7.01	163.38
Factor(B) at same level of A	NS	0.24	0.32	0.13	2.31	3.75	9.36	20.22	14.60	350.44
Factor(A) at same level of B	NS	0.26	0.31	0.13	2.56	3.66	9.23	20.49	14.25	351.94

Where Factor A= Treatment, Factor B = Varieties

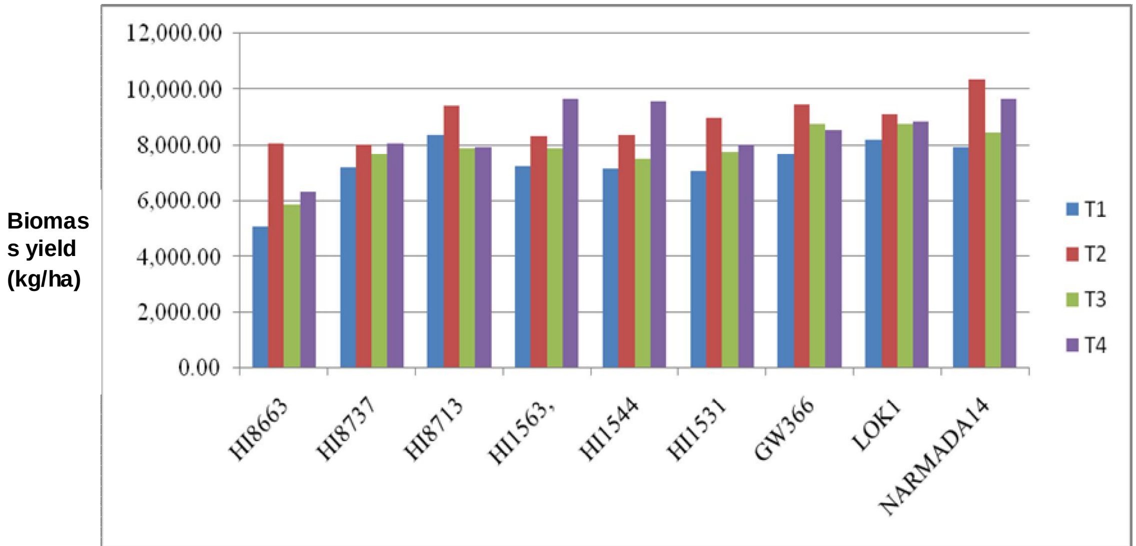

Fig. 1. Effect of N & P on biomass yield of wheat genotypes

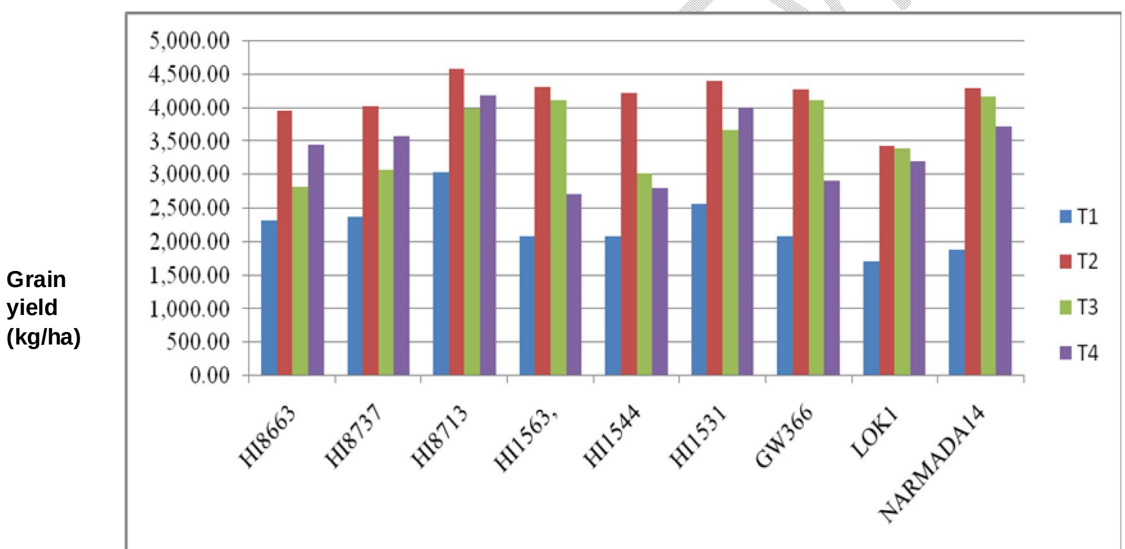

Fig. 2. Effect of N & P on grain yields of different wheat genotypes

4 Summery and Conclusion

a. Normal RDFs of nitrogen and phosphorus increased the plant height of wheat, but low N conditions resulted in the lowest plant height. The wheat genotype HI 1544 (87.63 cm) had a greater mean plant height, whereas HI 8663 (71.38 cm) had a lower mean plant height. Varieties GW366 (91 cm) grown under optimum N with a sub-optimal P dose, on the other hand, exhibited higher plant heights comparable to an optimum dose of both N and P. Normal RDF of nitrogen and phosphorus increased the dry matter weight of the plant at all three stages of growth, 50, 65, and 85 DAS. At 85 DAS, NARMADA14 (3.06 g/plant) had the highest dry matter weight, followed by LOK1 (2.83 g/plant).

Early flowering was observed with nitrogen and phosphorus fertilization, but it was delayed by a few days in control plots. In the current study, the control condition may have resulted in nitrogen deficiency, which may have caused flowering to be delayed by a few days. Varieties grown under normal RDF (T2) had a higher leaf area. HI 1531 (171.13 cm^2) at 65 DAS and NARMADA 14 (169.38 cm^2) at 85 DAS exhibited the highest mean leaf area among all the varieties.

The variety HI8713 produced a significantly larger plant biomass of 8383.00 kg/ha, 9,393.00 kg/ha, 7,913.25 kg/ha, and 7,948.25 kg/ha under normal, reduced N and P dose conditions, and control fertilizer doses. The same variety produced considerably higher grain yields of 3,035.13 kg/ha, 4,580.88 kg/ha, 3,996.63 kg/ha, and 4190.88 kg/ha, respectively, under similar fertilizer doses.

b. Among all the wheat varieties tested, variety HI 8713 had considerably higher dry weight, leaf area, biomass, grain yield, and lower days to 50% flowering, In terms of mean grain yield cutting across all the treatments, the selected nine varieties followed the trend

HI8713>HI1531>NARMADA 14>GW366>HI1563>HI8737>HI8663>HI1544>LOK1

c. The recommended dose of N, P, and K in treatment T_2 performed the best in terms of yield attributes (grain yield, leaf area, and dry matter) in all nine selected wheat varieties, while treatment T_1 performed the least productive. In sub-optimal doses of N and P (T_3 and T4), T_3 produced a higher biomass yield than T_4, averaging all the selected nine varieties of wheat, whereas T_4 had a higher grain yield than T_3.

References

1. BELETE, Fresew, *et al.,* Effect of nitrogen fertilizer rates on grain yield and nitrogen uptake and use efficiency of bread wheat (*Triticum aestivum* L.) varieties on the Vertisols of central highlands of Ethiopia. Agriculture & Food Security, 2018, 7(1): 1-12.

2. BENIN, Giovani, *et al.,* Agronomic performance of wheat cultivars in response to nitrogen fertilization levels. Acta Scientiarum. Agronomy, 2012, (34): 275-283..

3. BREZOLIN, Ana Paula, *et al.,* The efficiency of wheat yields by nitrogen dose and fractionation. African Journal of Agricultural Research, 2016, 11(36): 3440-3449.

4. IRFAN, Muhammad, *et al.,* Internal and external phosphorus requirements for optimum grain yield are associated with P-utilization efficiency of wheat cultivars. Communications in Soil Science and Plant Analysis, 2018, 49(22): 2843-2853.

5. KAUR, G.; ASTHIR, B.; BAINS, N. S. Nitrogen levels effect on wheat nitrogen use efficiency and yield under field conditions. African Journal of Agricultural Research, 2015, 10(23): 2372-2377.

6. KHURSHEED, Mohammed Q.; MAHAMMAD, Maqsuda Q. Effect of different nitrogen fertilizers on growth and yield of wheat. Zanco J. Pure Appl. Sci, 2015, 27(5): 19-28.

7. MAHESWARI, M.; MURTHY, A. N. G.; SHANKER, A. K. Nitrogen nutrition in crops and its importance in crop quality. In: The Indian nitrogen assessment. Elsevier, 2017. (1). 175-186.

8. NASRI, Reza, *et al.*. Nitrogen uptake and utilization efficiency and the productivity of wheat in double cropping system under different rates of nitrogen. Int. J. Biosci, 2014, 4(4): 184-193.

9. PATEL, C. B., *et al.,* Response of different wheat (*Triticum aestivum* L. emend Fiori & Paol.) genotypes to various nitrogen levels under late sown conditions of Eastern Uttar Pradesh. *& Ecology*, 2012, 30(3C): 1192-1196.

10. REGINATTO, Douglas C., *et al.,* Sustainable optimization of nitrogen uses in oat at sowing and top-dressing stages. Australian Journal of Crop Science, 2021, 15(1): 23-31.

11. REHIM, Abdur, *et al.,* Integrated use of farm manure and synthetic nitrogen fertilizer improves nitrogen use efficiency, yield and grain quality in wheat. Italian Journal of Agronomy, 2020, 15(1): 29-34.

12. SALIM, Nazia; RAZA, Ali. Nutrient use efficiency (NUE) for sustainable wheat production: a review. Journal of Plant Nutrition, 2020, 43(2): 297-315.

13. TAHIR, Izzat Sidahmed Ali, *et al.,* Genetic gain in wheat grain yield and nitrogen use efficiency at different nitrogen levels in an irrigated hot environment. International Journal of Agronomy, 2020, (2020): 1-11.

14. Ata-Ul-Karim, S. T., Liu, X., Lu, Z., Yuan, Z., Zhu, Y., & Cao, W. In-season estimation of rice grain yield using critical nitrogen dilution curve. Field Crops Research, 2016,(*195)*, 1-8.

15. LIN, Ya-Ling; TSAY, Yi-Fang. Influence of differing nitrate and nitrogen availability on flowering control in Arabidopsis. *Journal of Experimental Botany*, 2017, 68. (10): 2603-2609.