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Impact of different levels of nitrogen on growth and yield of wheat crop (*Triticum aestivum* L) in the mid hill regions of Himachal Pradesh

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Abstract
A field experiment was carried out during the *rabi* season of 2022 at Research Farm of School of Agriculture, Abhilashi University, Mandi (H.P.). This study aimed to assess the impact of different levels of nitrogen on growth and yield of wheat (*Triticum aestivum* L) in the mid hill regions of Himachal Pradesh. The experiment was carried out in randomized block design with seven treatments and three replications. The treatments were comprised of different nitrogen levels *viz,*- T_1= Absolute control, T_2=50 kg N+ RDF- P&K, T_3=75 kg N+ RDF- P&K, T_4=100 kg N + RDF- P&K, T_5= 120 kg N+ RDF- P&K T_6=150 kg N+ RDF- P&K, T_7=175 kg N+ RDF- P&K. The results of experiment showed the significant effects of different nitrogen levels application on growth and yield of wheat crop. Among the different nitrogen levels, treatment T_7 (175 kg N+ RDF- P&K) recorded the highest value of all growth parameters [plant height (cm), number of tillers (m^{-2}) and dry matter accumulation (g m^{-2})], yield attributes [No. of effective tillers (m^{-2}), No. of spikes (m^{-2}), spike length (cm), No. of grains spike^{-1}] and yields [grain yield, straw yield and biological yield] of wheat crop, as compared to other treatments, while, it was statistically at par with treatment T_6 (150 kg N+ RDF- P&K). Whereas, test weight (g) and harvest index (%) of the wheat crop were found non-significant. However, the minimum values of all different parameters were recorded under treatment T_1 (Absolute control) during the field experiment. This study showed that the different levels of the nitrogen significantly affected the growth parameters, yield attributes and yields of the wheat crop in the mid hill regions of the Himachal Pradesh.

Keywords: Wheat, nitrogen, growth parameters, yield attributes and yield

Introduction
Wheat (*Triticum aestivum* L.) is the world′s most outstanding crop that excels all other cereals both in area and production, known as the king of cereals. It is primarily grown in temperate regions and also at higher altitude under tropical climate areas in winter season. It is the single most important cereal crop that has been considered an integral component of the food security system of the several nations. It ranks first in the world, among the cereals in respect of an area (204.34 million ha) and production (737.8 million tonnes). In India, it is grown an area of 30.22 million hectares with the production of 97.0 million tonnes (USDA) (Anonymous, 2016) [7]. In the world, China, India, USA, Pakistan, Turkey, UK, Argentina, Iran and Italy are the major wheat producing countries and contribute about 74.82% of the total wheat production. As far as India is concerned, about 91% of the total wheat production is contributed by northern states like Uttar Pradesh, Haryana, and Punjab, where Uttar Pradesh ranks first with respect to area (9.65 mill ha) and production (26.87 mill. tonnes) but the productivity is much lower (2784 kg/ha) as compared to Punjab and Haryana (4511 kg/ha) (Anonymous, 2016) [7]. As per second advance estimates for the agriculture year 2022-23, the wheat production in the country is estimated at 112.18 million tonnes which is higher by 4.44 million tonnes than the production achieved during 2021-22 (Anonymous, 2016) [7].

A major danger to the sustainability of India's food security is the yield standstill in wheat that has been noticed in recent years as a result of inadequate irrigation, fertilizer application, and soil deterioration. Some scientific research that focuses on the prudent application of nitrogen in wheat can help overcome this. Nitrogen is one of the major nutrients which reduce the yield of wheat if not applied in proper amount as it is needed for fast growth of plants and to get high production per hectare. Nitrogen fertilizer is known to affect the number of tillers m^{-2}, number of spikelet's $spike^{-1}$, number of Grains $spike^{-1}$, spike length and 1000-grain weight. Therefore, it is necessary to apply nitrogenous fertilizer in the soil to get bumper yields of wheat (Ali *et al*, 2000) [5]. In case of irrigated areas, the application of nitrogen up to 156 kg per ha showed an increasing trend of wheat grain yield i.e. 6472 kg per ha Heinemann *et al*, (2006) [11]. Espindula *et al*, 2010 [9] reported that to get the maximum yield of wheat the optimum rate of nitrogen application is 70-120 kg per ha. Nitrogen insufficiency influences biomass synthesis and use of sun energy for productivity of the plant, with an extraordinary effect on grain yield and yield contributing parameters (Heinemann *et al*, 2006) [11]. The inconsistency in soil and climatic conditions related with forms that influence nitrogen elements in the root zone and their association with the plant may prompt variation in nitrogen accessibility and its necessity to plant (Espindula *et al*, 2010) [9]. Furthermore, the arrival of new cultivars with various requirements for their nutrition upsets summed up proposals of nitrogen fertilizers for wheat crop. The enthusiasm for boosting wheat yields has urged progressive farmers to perform the farm management operations intensively. Optimal rates of fertilizer application to salt-affected soils partially alleviate the adverse effects of salinity on photosynthesis and photosynthesis-related parameters and yield components through mitigating the nutrient demands of salt-stressed plants (Sultana *et al*, 2001) [23]. The proper use of nitrogen fertilizer in saline soils where nitrogen may minimize the adverse effects of salinity on plant growth and yield (Albassam, 2001, Abdelgadir *et al*, 2005) [3, 1].

Average nitrogen use in crop production is surprisingly high, and above a certain amount, nitrogen utilizing effectiveness decreases (Peng *et al*, 2006, Zhang *et al*, 2006) [15, 12]. Declining nitrogen utilization effectiveness of irrigated crops augmented contamination due to quick loss of spent nitrogen through volatilization, denitrification, and leaching of nitrogen from fields (Liu *et al*, 2008) [13]. About 15 kg N ha^{-1} losses at optimal nitrogen levels, while conventional nitrogen application by farmers exceeded 100 kg N ha^{-1}. There are some key factors of genotypes like root system and nitrogen application rate etc. are responsible for the effectiveness of nitrogen uptake and utilization (Timsina *et al*, 2001, Deng *et al*, 2012) [26, 8]. Total nitrogen accumulation at the grain filling stage can significantly contribute to yield enhancement (Lin *et al*, 2006) [12]. In addition, increasing nitrogen recovery efficiency and optimizing nitrogen uptake can increase crop yields (Thakuria *et al*, 2009) [25]. Therefore, Nitrogen losses may be reduced by judicious use of Nitrogen without negotiating yield of crop (Cui *et al*, 2006, Zheng *et al*, 2007) [29, 28]. Management practices need to be researched so that farmers can increase yields, reduce production costs and ensure agricultural sustainability. From this perspective, the development and cultivation of high NUE wheat varieties can reduce the amount of nitrogen applied as fertilizer without reducing grain yield. Wheat NUE is estimated as poorer than 60% (Haile *et al*, 2012, Hawkesford, 2012, Duan *et al*, 2014) [30, 10, 31]. Based on the genotype used, the Nitrogen application at the rate of 80–120 kg N ha^{-1} consequences in a range of 28.8–40.0 kg of grain with 1 kg of Nitrogen uses (Rahman *et al*, 2011) [17].

Materials and Methods

Experimental site

The experiment entitled "Impact of different levels of nitrogen on the production and productivity of wheat (*Triticum aestivum* L) in the mid hill region of Himachal Pradesh" was carried out at the research farm of the School of Agriculture, Abhilashi University, Mandi (H.P.) during the rabi season of 2022-23. The experimental farm is situated at 30^0 32' N latitude and 74^0 53'E longitude, with an elevation of 1391 m above mean sea level. During the crop growth season November 2022 to May 2023, the maximum temperature ranged between 13.07 to 29.84 ^{0}C and minimum temperature ranged between 3.12 to 17.64 ^{0}C, respectively. The maximum and minimum temperature was observed in 20^{th} and 3^{rd} standard week, respectively. The maximum total rainfall of 410.87 mm was received during the crop season. The maximum weekly rainfall of 74.75 mm was received during 16^{th} standard week. The weekly mean relative humidity ranged between 42.13 to 73.64 percent. The maximum relative humidity of 73.64 percent was observed in 18^{th} standard week (Fig 1.).

Edaphic conditions

Soil samples from 0-15 cm depth were collected from all the field separately before sowing of the wheat crop and were air dried, crushed, passed through 2 mm sieve and then soil testing was done for soil pH, EC (ds m^{-1}), organic carbon, available NPK concentration. The soils of the experimental field was slightly acidic in reaction, medium in organic carbon, low in nitrogen and medium in phosphorus and potassium.

The observations of different parameters were recorded as follow during field experiment:

Table 1: Initial soil parameters of the experimental soil

Sr. No.	Parameters	Values obtained	Methods of analysis Reference
1	pH (1:2.5, soil: water suspension)	5.54	Potentiometric (Page *et al.* 1982) [32]
2	EC (ds m^{-1})	0.29	EC meter (Page *et al.*, 1982) [32].
3	Organic carbon (%)	0.43%	Rapid titration method (Walkley and Black 1934) [33]
4	Available N	263.09	Alkaline permanganate method (Subbiah and Asija 1956) [34]
5	Available P	23.59	Olsen's method of extraction with 0.5N $NaHCO_3$ at pH 8.5 (Olsen *et al.* 1954) [35]
6	Available K	278.11	Ammonium acetate extraction method (Jackson, 1973) [36]

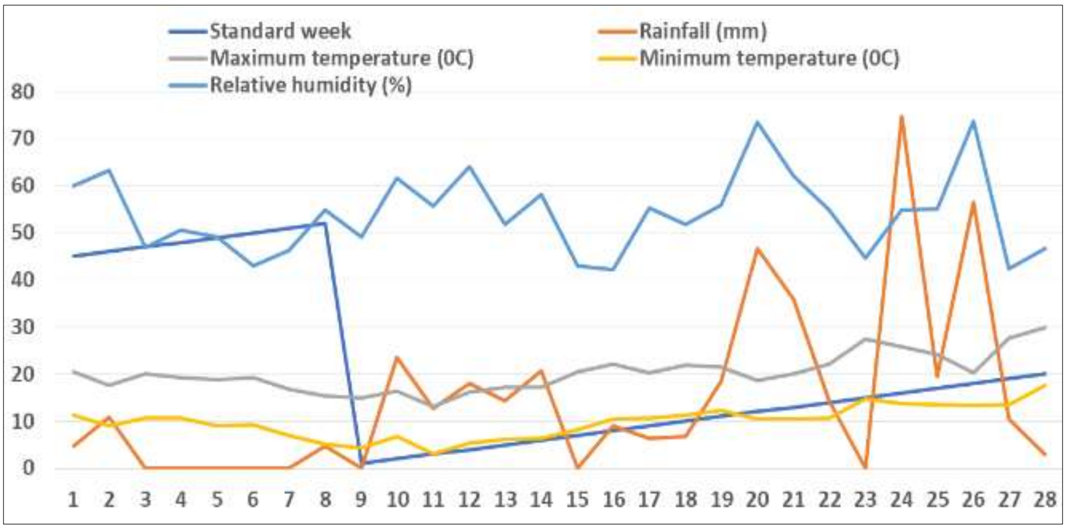

Fig 1: Mean weekly whether data experiment

Plant height (cm): The plant height of the plant was recorded from five randomly tagged plants at 30, 60, 90 DAS and at harvest stage from ground to tip of the longest leaf.

Dry matter accumulation (gm^{-2}): For dry matter, plants were harvested, first sun-dried and then oven-dried at 72 °C until it achieved a constant weight.

Number of tillers (m^{-2}): A tiller area of 1 m^2 was marked inside the net plot, and data were collected.

Number of effective tillers: Total no. of tillers was counted by using a quadrate of one square meter in each plot.

Number of spikes (m^{-2}): Total no. of spikes was counted by using a quadrate of one square meter in each plot at the time of harvest.

Spike length: Five spikes will be selected randomly and their length measured. Figures of all the five spikes will be added and sum will be divided by 5 to get spike length. It will be recorded in cm.

Grains per spike: It is determined by the combination of number of spikelets per spike and the number of grains per spikelet.

Test weight of grains (1000 – grain's weight): To calculate the thousand seed weight, divide the total weight in grams by the total number of seeds, then multiply by 1000.

Yield (q/ha): Similarly, grain and straw yields are collected from the net plot area. Plants from the net plot area were harvested at 195 DAS, threshed, sun dried, and maintained at 12% moisture and weighed after threshing straw weight was taken immediately.

Statistical analysis: According to the methodology outlined by Gomez (1984) [37], the data so acquired from the field and the lab were subjected to analysis. When the effects showed significance at the 5% probability level, critical difference (CD) was determined.

Results and Discussion

Growth parameters

Plant height

There was rapid increased recorded in height of plant from 30 to 90 days after sowing thereafter, increased in height was rather slow. Maximum plant height (109.95) was recorded under T_7 (175 kg N+RDF- P&K) at harvest stage, which was at par with T_6 (175 kg N+RDF- P&K) *i.e.*, 105.14 (Table 2.). Higher nitrogen levels results on increased in height of the plant. The maintenance of proper and continuous nitrogen supply to the crop helped in greater root establishment due to increased meristematic activities which contributed to rapid cell division, cell elongation and thus led to taller plant under the treatment. The lowest height at harvest was recorded under T_1 treatment (74.47) (absolute control) due to poor cell division as the result of poor meristematic activities caused by un-availability of nitrogen at critical stages. The reason behind could be that providing more nitrogen to the plant along with proper balance of all the nutrients enhanced the cell division and expansion consequently, resulted into tallest plant, profuse tillering and greater number of green leaves. This result is in correlation with those of Stupar *et al.* (2021) [22] and Singh *et al.* (2018) [20]. Ali *et al*. (2003) [6] also reported that there was a gradual increase in plant height with each successive dose of nitrogen.

Number of tillers (m^{-2})

Maximum numbers of tillers at harvest stage were recorded under T_7 (175 kg N+RDF- P&K) (445.31) which was at par with T_6 (150 kg N+RDF- P&K). This might be due to least plant competition for nutrient caused by sufficient supply of nitrogen which increased by better absorption of nutrient from the soil. The lowest numbers of tillers were recorded under the T_1 treatment where was absolute control (180.54). Similar result was found by Ali *et al.* (2011) [38] they experimented with different levels of nitrogen (0, 80, 130 and 180 kg N ha^{-1}) reported that 130 kg N ha^{-1} produced maximum number of tillers m^{-2} which was statistically at par with 180 kg N ha^{-1}.

Dry matter accumulation (gm^{-2})

Initially the rate of dry matter production in all the treatment was slow but it increased steadily till harvest. Different nitrogen levels had significant effect on dry matter accumulation at all the successive stages of plant growth except 30 DAS. Maximum dry matter accumulation was recorded under T_7 (175 kg N+ RDF- P&K) (1006.49) at harvest stage. This might be due to higher collective contribution of various growth characters like plant height, number of tillers. The rate of increase in dry matter production was slow during initial stage due to slow crop growth but it increased rapidly at later stages up to harvest due to bright sunshine and rise in temperature. As the result of this more dry matter accumulation in root, stem leaves and grains which favoured to increase the dry weight under this treatment. The lowest dry matter accumulation was recorded under treatment T_1 (Absolute control) (850.71). This could be mainly due to the fact that growing plant did not achieve sufficient nitrogen to poorer growth of the crop which consequently resulted into lowest dry weight. Dry matter accumulation by plant continued to increase at successive growth stages and the highest dry matter accumulation was recorded at maturity (Alam *et al*. (2022) [2]. Singh *et al*. (2013) [21] also reported that dry matter accumulation increased with increase in N rate up to highest level of 150 kg N ha^{-1} which was at par with 125 kg N ha^{-1} and significantly superior to 100 kg N ha^{-1}.

Yield parameters

Number of effective tillers (m^{-2})

The tillers bearing panicles of wheat crop are termed as effective tillers. The number of effective tillers m^{-2} was affected by various nitrogen levels. The maximum number of effective tillers were recorded under T_7 (424.62) (175 kg N+RDF - P&K) in comparison to lower nitrogen levels. This might be due to enhanced tillering, enhanced photosynthetic area, proper nourishment, more dry matter partitioning to sink and increased sink size at T_7 (175 kg N+RDF - P&K) which was at par with T_6 (150 kg N+RDF - P&K). However minimum number of effective tillers in absolute control T_1. These results are in conformity with Patel *et al.* (2018) [39], who concluded that, sufficient availability of nitrogen has stimulatory impact on tillering of wheat through synthesis of cytokines and rapid conversion of synthesized carbohydrates, which results to rapid multiplication and increase the size and number of growing cell thus results more number of effective tillers.

Number of spike (m^{-2}) and spike length (cm)

Maximum number of spike m^{-2} (420.02) and length of spike (15.32), were recorded under T_7 (175 kg N+RDF - P&K) as compared to other treatments (Table 2). The lowest value of yield attributing characters were obtained under T_1 (Absolute control) *i.e.* 168.73 and spike length (7.87) which resulted into reduced translocation of photosynthates from source of sink and thus led to poor growth and various yield attributes.

Grain spike^{-1}

The treatments significantly influenced number of grain per spike (Table 4.4). Number seeds per spike were also significantly affected by the different levels of nitrogen application. Maximum number of seeds/ spike were recorded under T_7 (51.46) (175 kgN + RDF- P&K) which was at par with treatment T_6 (47.99) that were also statistically similar to T_3 (75 kgN + RDF- P&K), T_4 (100 kgN + RDF- P&K), T_5 (120 kgN + RDF- P&K) while minimum number of grains per spike (26.21) was observed in T_1 (Absolute control) no nitrogen applied. Nitrogen fertilizer applied in optimum dose decrease the chance of seeds to deteriorate in the spikes otherwise in case of seed deterioration grain yield reduced Meena *et al*. (2018) [14].

Test weight (1000-grains weight)

The test weight of wheat crop was not varied significantly among the various nitrogen levels. Due to variation in nitrogen levels 1000 grain weight was non-significantly varied. Meanwhile maximum 1000 grain weight was found in T_7 (175 kg N + RDF - P&K) (43.69) followed by T_6 (150 kg N + RDF - P&K) (42.78), while where nitrogen was not applied T_1 (Absolute control) recorded the minimum grain weight (37.12). These results indicate the nitrogen has a key role in the growth and development of grain. Among the different levels of nitrogen, 1000-grain weight increased significantly with increasing fertilizer levels. This can be due to adequate supply of all the nutrients which produced the heaviest grain. Also, nitrogen availability at this time increases grain filling duration by delaying senescence to some extent as observed by Yang *et al.* (2000) [27]. The results are in confirmation with Singh *et al.* (2018) [20] and Rana *et al.* (2012) [18].

Yields

Grain and straw yield (qha^{-1})

Grain yield of wheat was significantly influenced by different nitrogen management practices. Treatment T_7 (175 kg N+RDF- P&K) recorded the highest grain yield (53.87) of wheat and it was significantly higher than all other treatments (Table 6). Growth and yield parameters are positively correlated with grain yield. Whereas, the minimum grain yield (30.64) was recorded under T_1 (Absolute control). Maximum straw yield (65.06) was also found in treatment T_7 **(**175 kg N+RDF- P&K) which was at par with treatment T_6 **(**150 kg N+RDF- P&K) and the minimum straw yield was recorded in T_1 (Absolute control, 39.87). These findings are similar to Siddiqui *et al.* (2013) [19].

Biological yield (qha^{-1})

Among different nitrogen level management practices, treatment T_7 (175 kg N+RDF - P&K) (118.53) recorded significantly highest biological yield and it was at par with T_6 (150 kg N+RDF - P&K) (115.15) respectively. The lowest biological yield is recorded in treatment T_1 (Absolute control) (70.51) (Table 6). The other important reason for increase in grain yield of wheat with higher doses of fertilizers *i.e.,* 125 per cent RDF could be attributed to higher yield attributes, effective tillers, 1000-grain weight and number of grains per spike revealed by Quanqi *et al.* (2010) [40]. Similar result was found by Heinemann *et al.* (2006) [11].

Harvest index (%)

A glance of data pertaining to harvest index in table 6 reveled that there was no significant effect of treatments on the harvest index of the wheat crop. Maximum harvest index (46.97) was calculated from T_2 50 kg N + RDF - P&K while minimum harvest index (43.45) was calculated from T_1 (Control). When harvest index is low it means that there is less translocation of assimilates from the source to sink which results in less development of seeds and make them shrivled size. When harvest index is high it means that more assimilates were translocated from source to the grains which result in improved development and filling.

Table 2: Effect of different nitrogen levels on plant height (cm) of wheat crop

Treatments	30 DAS	60 DAS	90DAS	At harvest
Absolute Control	12.76	24.07	62.27	74.47
50 kg N + RDF - P&K	15.87	36.76	67.54	86.46
75 kg N + RDF - P&K	16.01	39.44	70.87	89.51
100 kg N + RDF - P&K	16.25	44.56	72.45	94.53
120 kg N + RDF - P&K	17.29	45.97	75.51	96.39
150 kg N + RDF - P&K	18.92	47.66	78.87	105.14
175 kg N + RDF - P&K	20.44	51.54	83.94	109.95
SEm^{+}	0.50	1.27	2.34	2.88
CD(P=0.05)	1.57	3.96	7.29	8.97

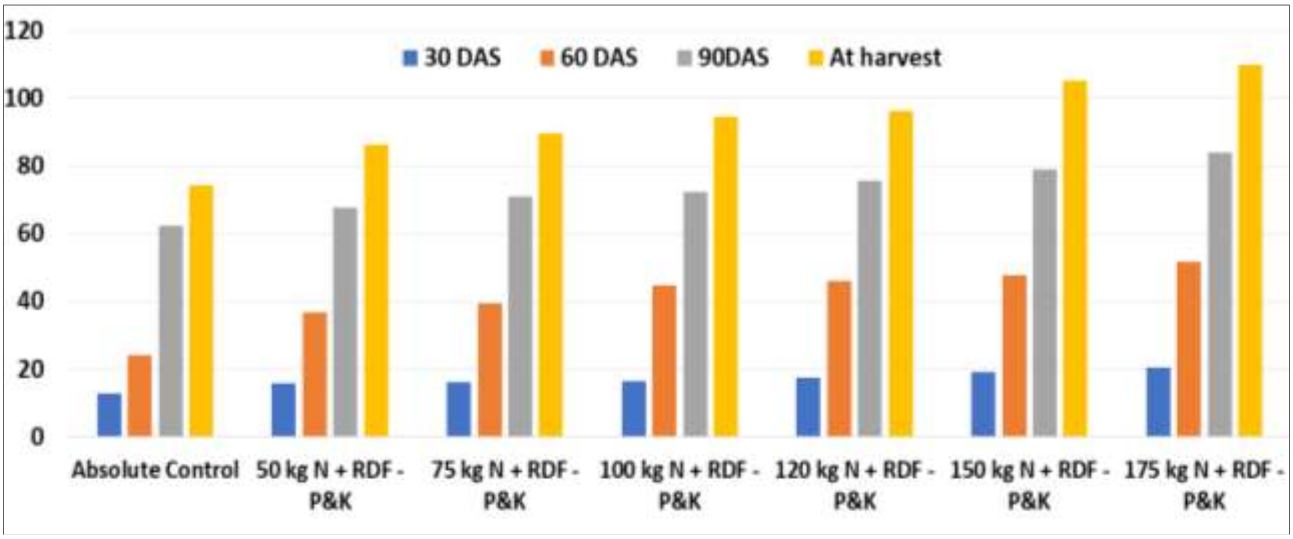

Fig 2: Effect of different nitrogen levels on plant height (cm) of wheat crop

Table 3: Effect of different nitrogen levels on number of tillers (m^{-2}) of wheat crop

Treatments	30 DAS	60 DAS	90DAS	At harvest
Absolute Control	160.86	190.64	180.54	171.87
50 kg N + RDF - P&K	172.03	250.64	232.21	210.78
75 kg N + RDF - P&K	179.32	298.65	289.31	275.42
100 kg N + RDF - P&K	181.54	354.87	334.75	322.43
120 kg N + RDF - P&K	182.87	401.76	385.09	365.34
150 kg N + RDF - P&K	183.87	469.45	440.58	419.20
175 kg N + RDF - P&K	185.76	471.79	445.31	434.31
SEm^{+}	5.30	10.10	9.98	10.09
CD(P=0.05)	NS	31.48	31.09	31.44

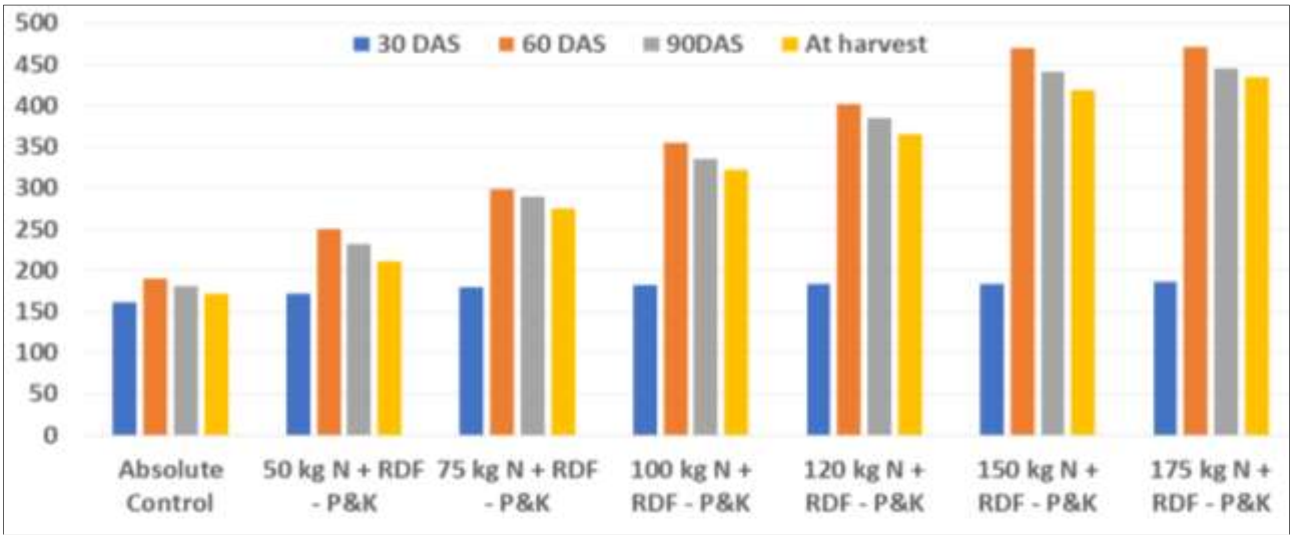

Fig 3: Effect of different nitrogen levels on number of tillers (m^{-2}) of wheat crop

Table 4: Effect of different nitrogen levels on dry matter accumulation (gm^{-2}) of wheat crop

Treatments	30 DAS	60 DAS	90DAS	At harvest
Absolute Control	85.42	349.97	550.20	850.71
50 kg N + RDF - P&K	96.64	356.65	562.23	863.86
75 kg N + RDF - P&K	108.21	399.18	602.68	870.92
100 kg N + RDF - P&K	112.63	432.78	631.11	881.98
120 kg N + RDF - P&K	128.94	448.59	665.18	904.91
150 kg N + RDF - P&K	159.25	473.91	722.59	948.40
175 kg N + RDF - P&K	170.10	499.99	749.89	1006.49
SEm^{+}	3.94	13.73	21.54	30.37
CD(P=0.05)	12.28	42.78	67.10	94.64

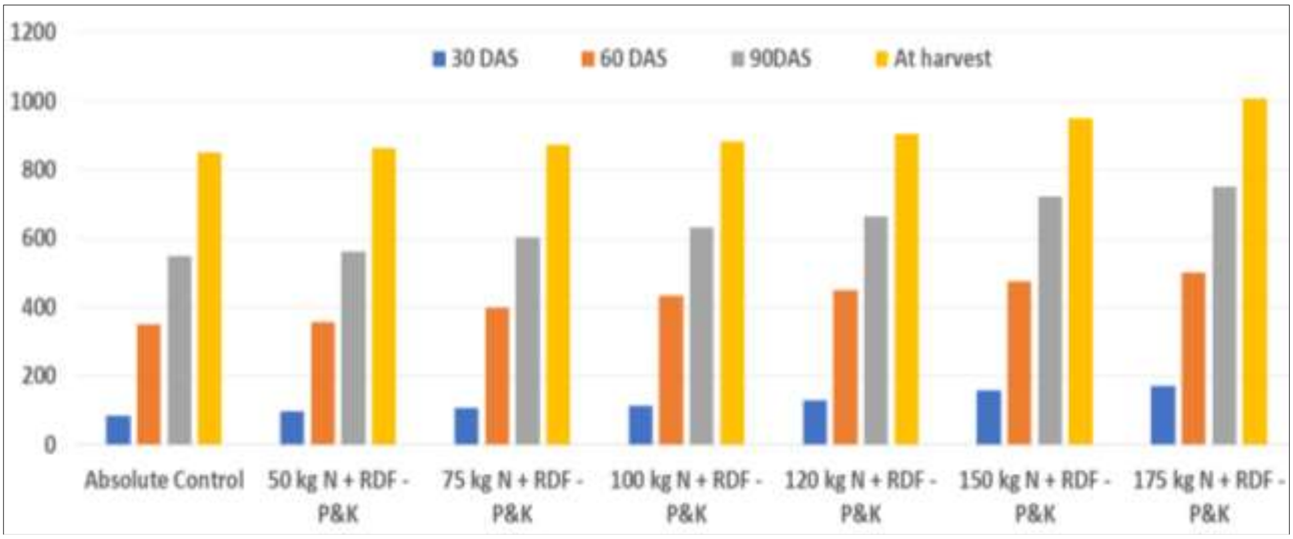

Fig 4: Effect of different nitrogen levels on dry matter accumulation (gm^{-2}) of wheat crop

Table 5: Effect of different nitrogen levels on different yield attributes of wheat crop

Treatments	No. of effective tillers (m^{-2})	No. of spikes (m^{-2})	Spike length (cm)	No. of grain spike^{-1}	Test weight (1000-grains weight)
Absolute Control	171.50	168.73	7.87	26.21	37.12
50 kg N + RDF - P&K	225.58	221.47	9.11	30.25	39.10
75 kg N + RDF - P&K	268.02	264.21	9.83	33.42	40.24
100 kg N + RDF - P&K	319.39	316.92	12.21	38.58	41.21
120 kg N + RDF - P&K	361.59	359.91	13.52	41.34	42.11
150 kg N + RDF - P&K	422.51	417.11	14.57	47.99	42.78
175 kg N + RDF - P&K	424.62	420.02	15.32	51.46	43.69
SEm^{+}	30.06	28.24	1.09	4.07	NS
CD(P=0.05)	9.65	9.06	0.35	1.30	1.394

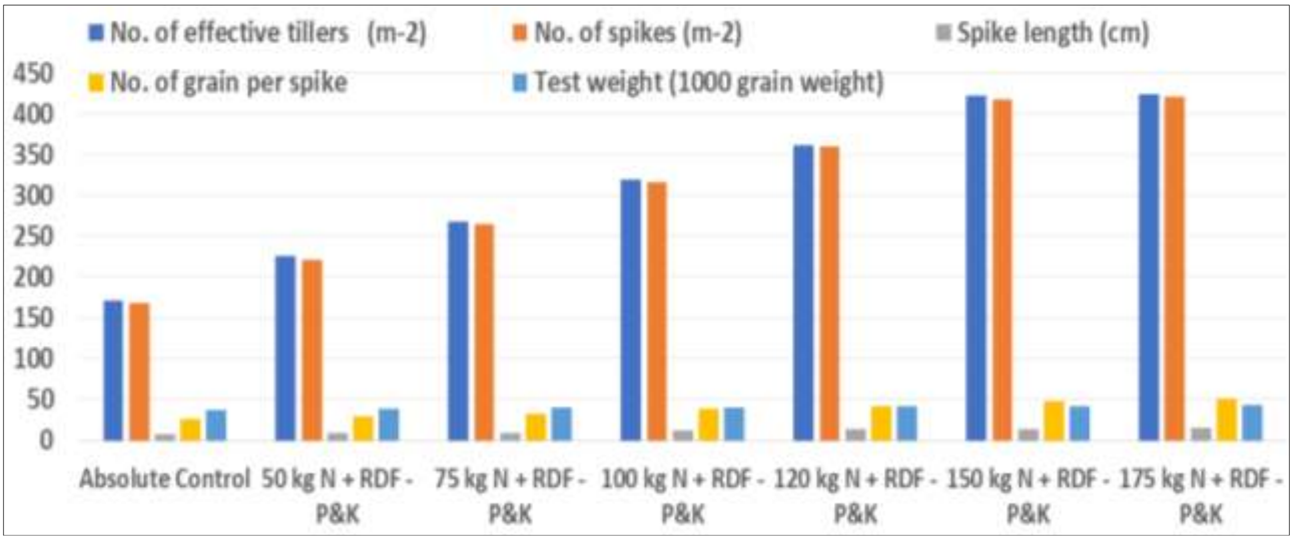

Fig 5: Effect of different nitrogen levels on different yield attributes of wheat crop

Table 6: Effect of different nitrogen levels on yields and harvest index of Wheat crop

Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Biological yield (q/ha)	Harvest index (%)
Absolute Control	30.64	39.87	70.51	43.45
50 kg N + RDF - P&K	40.44	45.65	86.09	46.97
75 kg N + RDF - P&K	42.88	52.72	95.60	44.85
100 kg N + RDF - P&K	45.32	54.76	100.08	45.28
120 kg N + RDF - P&K	47.13	58.71	105.84	44.52
150 kg N + RDF - P&K	51.39	63.76	115.15	44.62
175 kg N + RDF - P&K	53.87	65.06	118.93	45.29
SEm+	1.358	1.74	2.91	1.44
CD(P=0.05)	4.23	5.44	9.06	NS

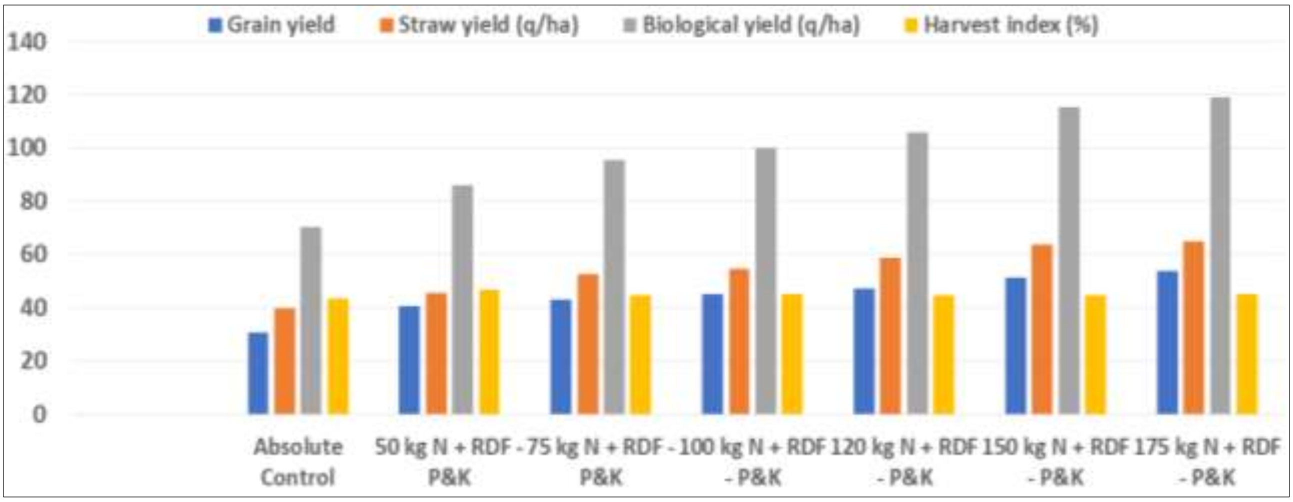

Fig 6: Effect of different nitrogen levels on yields (qha^{-1}) and harvest index of Wheat crop

Conclusion

The combination of different nitrogen levels in the current study reveled significant variations for growth and yield of wheat. On the basis of above findings, it can be concluded that the treatment T_7 (175 kg N+RDF- P&K) plots were the best in terms of growth parameters (*viz*., plant height, number of tillers, dry matter accumulation), yield attributes (number of effective tillers, number of spikes, spike length, number of grain per spike and test weight) and yields of wheat crop which was at par with T_6 (150 kg N+RDF-P&K). The application of treatment T_7 (175 kg N+RDF-P&K) show best result for growth and yield as compare to other treatments.

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Conflict of Interest

None.

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