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Growth and yield of wheat (*Triticum aestivum* L.) as effected by split application of nitrogen and phosphorus

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Abstract
An experiment was conducted at experimental farm of Chandigarh University, Mohali, Punjab, during Rabi season of 2020-2021 to study "Effect of split application of nitrogen and phosphorus on growth and yield of wheat (*Triticum aestivum* L.)." The treatments consisted of various combination of nitrogen along with phosphorus (T1-Nitrogen 125% + Phosphorus 100%, T2- Nitrogen 125% + Phosphorus 75%, T3- Nitrogen 100% + Phosphorus 100%, T4- Nitrogen 100% + Phosphorus 75%, T5- Nitrogen 75% + Phosphorus 100%, T6- Nitrogen 75% + Phosphorus 75% and control). Experiment was conducted under randomized block design (RBD) with three replications. It was concluded that there is increase in spike length (22.47%), number of grain (10.19%), test weight (11.59%), grain yield (15.15%), straw yield (13.10%) and harvest Index (2.01%) with the combined application of nitrogen and phosphorus in treatment T7 (125 kg N/ha +75 kg P/ha) as compared to control. Overall results indicate that in treatment T7 combination of nitrogen along with phosphorus is effective for better growth and yield of wheat as compared to others treatments.

Keywords: biomass, nitrogen, phosphorus, harvest index, yield

Introduction
Wheat (*Triticum aestivum* L.) is second most important cereal crop in the world after rice and is one of the most important stable food crop. Wheat is one of the most important cereal crops as it serves as an excellent source of carbohydrate for mankind. The main wheat producers in the European Union are France, Germany, the United Kingdom, Romania, and Poland. China and India are major wheat producing country of Asia, China, India Russia, United States and France are the major wheat producing countries (FAOSTAT, 2019) [7]. It is the second most important cereal in India after rice. Wheat cultivation in India has been traditionally dominated by the northern region of India. Nitrogen is responsible for early growth of the plant. If it is available to the plant at the time of its need, there will be positive response by the plant. Wheat crop shows significant response when nitrogen is applied half as a basal dose and half at first irrigation. When nitrogen is applied at the later stages of growth several growth quality parameters of the wheat crop increases. However, nitrogen is applied as half dose as a basal and half is applied as top dressing at first irrigation both in medium and heavy soils. Many researchers have concluded that when nitrogen is applied in split dose it is more effective and having better performance. Splitting of the nitrogen dressing throughout the growing season is advantageous, since it allows farmers to anticipate the actual growing conditions. Several field studies have been conducted on nitrogen fertilizer balances, demonstrating that nitrogen fertilizer efficiency largely depends on the local environmental conditions and agricultural practices. Therefore, split application nitrogen has to be a major factor for the increase in the yield (Anwar *et al*., 2016) [2]. Phosphorus is essential for many physiological processes. Phosphorus application at proper time, in optimum quantity through proper method of application is essential to increase crop production and its sustainability. Considering the key role of N and P in crop productivity, this research study was planned to evaluate the effect of various phosphorous and nitrogen levels on wheat varieties.

Material and Methods
The present work entitled "Effect of split application of nitrogen and phosphorus on growth and yield of wheat (*Triticum aestivum* L.)" was carried out during Rabi season of 2020-2021 at research farm of University Institute of Agricultural Sciences, Chandigarh University, Gharuan, Mohali (Punjab). The experiment was conducted in a randomized complete block design with three replications**.** The experiment was laid out with the following treatments T1 (Nitrogen 125% and Phosphorus 100%), T2 (Nitrogen 125% and Phosphorus 75%), T3 (Nitrogen 100% and Phosphorus 100%), T4 (Nitrogen 100% and Phosphorus 75%), T5 (Nitrogen 75% and Phosphorus 100%), T6 (Nitrogen 75% and Phosphorus 75%), T7 (Control). The half dose of nitrogen through urea and full dose of phosphorus was applied as basal dose at sowing. The remaining half dose of nitrogen was top dressed at first irrigation. Wheat was sown with a row spacing of 22.5 cm. Wheat variety "Unnat PBW-343" was sown using seed rate of 100 kg/ha in first week on well prepared seed bed in December, 2020. Various observations were recorded during the experiment *viz*., spike length, number of grains/spike, test weight (g), grain yield (q/ha), straw yield (q/ha), biological yield (q/ha) and harvest index. The experimental data collected during the course of investigation were subjected to statistical analysis by 'Analysis of variance 'technique as described by Fisher (1958). Value from Fisher's table (1948) for error degree of freedom at 5% level of significance was considered.

Results and Discussions

Growth and yield attributes

The data pertaining to growth parameters has been presented in Table 1. The maximum number of tillers per plant were recorded in treatment T2 (396.77) followed by T3 (386.40) while, minimum number of tillers per plant were recorded at treatment T7 (367.51). An increase in number of tillers per plant by 7.37% were observed in T2 treatment as compared to control. The maximum number of tillers per plant were recorded in treatment T2 (396.77). This may be due to application of nitrogen along with recommended nutrient dose. A similar effect of nitrogen on tillers per plant has been reported (Otteson *et al*, 2007; Qadeer *et al*, 2019) [13, 14]. In mean value, effective number of tillers ranged from 1.54 to 1.82. Maximum effective number of tillers were recorded at T2 treatment (1.82) followed by T4 (1.73) while, minimum effective number of tillers were recorded at T6 (1.54). As compared to T2 with T7 showed 9.89% increase in effective number of tillers. These observations may be due to application of optimum nitrogen along with recommended nutrient dose. Similar results have been earlier reported that nitrogen concentration has direct influence on the effective number of tillers (Qadeer *et al*, 2019; Handa *et al*, 2019) [14, 9].

Maximum spike length was recorded at T1 treatment (8.63 cm) followed by T2 (7.69 cm) while the minimum length of spike was recorded in control (6.69 cm) (Table 1). As compared to T7 with T1 showed 22.47% increase in length of spike. Longer spike can accommodate more number of grains and subsequently more yield. Hussain *et al.* (2006) reported that nitrogen and phosphorus has direct influence on spike length. These results are in accordance with finding of Bhardwaj *et al.* (2010) [4] with 120 kg N/ha in wheat. Similar results have been reported earlier in wheat crop (Maqsood *et al.* 2014; Debnath *et al.* 2014) [12, 6]

The data related to number of grains per spike has been presented in Table 1. Grains per spike ranged from 39.15 to 48.37. Highest number of grains per spike was recorded at T2 treatment (48.37) followed by T3 and T6 having the nearly similar value of 45.77 and 43.44, respectively.

This might be due to optimum nitrogen level along with phosphorus. Likewise, Afridi *et al.* (2014) [1] reported that combination of 120 Kg N/ha and 75 Kg P/ha increased the number of grains per spike.

The data regarding 1000-grain weight of wheat as influenced by fertilizer application methods and inoculation are presented in Table 1**.** Maximum 1000-grain weight were recorded for T2 treatment (37.85 g) followed by T3 (35.33 g). There is increase in 11.59% in 1000-grain weight in T2 treatment as compared to control. Earlier reports have shown that nitrogen and phosphorus has direct influence on test weight of grain (Ghafoor *et al.* 2021) [8]. As evident form Table 1, straw yield ranged between to 34.48 q/ha to 43.51 q/ha. The highest straw yield was recorded at T2 (43.51 q/ha) followed by T3 (41.18 q/ha) while the lowest straw yield was recorded at T7 (34.48 q/ha). Similar results have been reported in wheat crop (Dai *et al.* 2016, Belete *et al.* 2018) [5, 3]. Harvest index varied between 34.30 to 38.02 % depending upon treatments. Highest harvest index was recorded for T3 (38.02 %) as compared to control. There is increase in harvest index by 2.01% in T3 as compared to control (Table 1). Harvest index is capability of crop to convert total dry matter of crop into economic yield. Higher harvest index shows more physiological potential of crop to convert the total dry matter into grain yield. Likewise, Ghafoor *et al.* (2021) [8] observed similar results in wheat crop.

Table 1: Effect of nitrogen and phosphorus treatments on yield attributes in wheat

Treatments	Number of tillers/plant	Number of effective tillers	Spike length (cm)	Number of grains pike/plant	1000 grain weight (g)	Grain Yield (q/ha)	Straw Yield (q/ha)	Harvest Index (in %)
Nitrogen 125% + Phosphorus 100%	380.13	1.70	8.63	43.10	33.91	23.11	39.33	37.00
Nitrogen 125% + Phosphorus 75%	396.77	1.82	7.69	48.37	37.85	26.46	43.51	37.81
Nitrogen 100% + Phosphorus 100%	386.40	1.67	7.43	45.77	35.33	25.25	41.18	38.02
Nitrogen 100% + Phosphorus 75%	378.09	1.73	7.25	41.81	33.65	22.59	40.26	35.94
Nitrogen 75% + Phosphorus 100%	371.00	1.61	6.80	41.81	33.46	19.63	37.57	34.30
Nitrogen 75% + Phosphorus 75%	379.24	1.64	7.18	43.44	33.48	22.45	37.85	37.22
Control	367.51	1.54	6.69	39.15	32.37	18.80	34.48	35.30
SEm (±)	1.76	0.02	0.12	0.68	0.45	0.51	0.60	0.59
LSD (P=0.05)	5.48	0.05	0.39	2.10	1.42	1.61	1.89	1.84

SEm (±): Standard error of mean, LSD: Least Significant Difference

Economics study

The data presented in Table 2 revealed that that maximum cost of cultivation (Rs. 40700 /ha) was recorded in T1 (Nitrogen 125% + Phosphorus 100%) while minimum cost of cultivation was recorded in control (Rs. 29462/ ha). This might be due to high dosage of nitrogen and phosphorus application as compared with control and other treatments. Maximum gross return (Rs. 66236.1/ha) was observed in T2 (Nitrogen 125% + Phosphorus 75%) as compared with control (Rs. 36545.3/ha) and other treatments. Minimum gross return was observed in T6 (Rs. 49648.9/ha) due to low yield of grain and straw. Similarly, application of 60 kg N/ha gave maximum gross return as compared to combination of organic and inorganic nutrients (Rabi *et al.* 2019). Maximum net returns (Rs. 26136.1/ha) were recorded under T2 (Nitrogen 125% + Phosphorus 75%) due to higher grain yield and straw yield as compared with control (Rabi *et al.* 2019). The highest benefit is to cost ratio was recorded at T2 (0.65) followed by T3 (0.51) while the minimum was recorded at T5 (0.21).

Table 2: Effect of different treatments on economics of wheat production

Treatments	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net Returns (Rs/ha)	B:C ratio
Nitrogen 125% + Phosphorus 100%	40700	58369.5	17669.5	0.43
Nitrogen 125% + Phosphorus 75%	40100	66236.1	26136.1	0.65
Nitrogen 100% + Phosphorus 100%	40550	61161.8	20611.8	0.51
Nitrogen 100% + Phosphorus 75%	39950	52326.5	12376.5	0.31
Nitrogen 75% + Phosphorus 100%	40400	48800.3	8400.3	0.21
Nitrogen 75% + Phosphorus 75%	40100	49648.9	9548.9	0.22
Control	29462	36545.3	7083.3	0.24
SEm (±)		1455.2	1455.2	0.01
LSD (P=0.05)		4512.2	4512.2	0.03

SEm (±): Standard error of mean, LSD: Least Significant Difference

Conclusion

It was concluded that application of different nitrogen and phosphorus in right combination has significant effect on morphological and yield traits of wheat. A prominent increase in economic and biological traits of wheat were noticed when plant received higher dose of nutrients in form of 125 kg N/ha and 75 kg P/ha. Addition of phosphorus and nitrogen increased agronomic traits namely grains per spike, test weight, grain yield, straw yield and harvest index. Application of 125 kg N/ha and 75 kg P/ha increased spike length (22.47%), number of grain (10.19%), test weight (11.59%), grain yield (15.15%), straw yield (13.10%) and harvest Index (2.01%). Nitrogen along with phosphorus is clearly responsible for better trait of wheat so, it can be adopted for more increment in quality and yield of wheat crop. Overall result indicates that nitrogen along with phosphorus is clearly responsible for better growth and agronomic trait of wheat. Right combination of nitrogen and phosphorus can be adopted for obtaining better yield of wheat crop.

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