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Effect of Nitrogen and Phosphorus Fertilization on The Growth and Yield of Wheat (*Triticum Aestivum L.*)

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Abstract

A field experiment was conducted during winter (Rabi) season of 2018-19 at Agricultural Research Farm, Department of Agronomy, R.B.S. College, Bichpuri, Agra (U.P.) the investigation entitled "Effect Of Nitrogen And Phosphorus Fertilization on The Growth and Yield of Wheat (Triticum Destivum L.)". The variables involve in this study four nitrogen levels viz. N_1 (50 kg ha), N_2 (100 kg ha), N_3 (150 kg ha) and N_4 (200 kgha^{-1}) was sown with four phosphorus levels viz. PO (0 kg ha^{-1}), P_1 (30 kg ha), P_2 (60 kg ha) and P_3 (90 kgha). Thus in all 16 treatments combinations were compared in a Randomized Block Design (RBD) having cultivars sown in main plots nitrogen levels and sub plot in phosphorus levels with four replications. The experimental results revealed that Based on the results of present investigation it is inevitable that nitrogen level 150 kg ha when applied with phosphorus @ 60 kg P_2O_5 ha played a vital role for overall improvement in crop growth as judged by increased growth, yield attributes and yield of wheat crop.

Keywords: Growth, Yield, Productivity, Nitrogen, Phosphorus, wheat.

Introduction

Wheat (*Triticum aestivum* L.) is the world's most widely cultivated food crop, occupying the prime position among food crops in the world. It is eaten in various forms by more than one thousand million human beings in the world (Iftikhar et al., 2002). It is used as a staple food by 10 billion individuals over all the world mainly in 43 countries and contributing 30% to overall grain demand of the world standing at top in cereal crops. It gives around 20% of the aggregate food calories for mankind (Ali, et al. 2018)

It is the most important grain crop of the World, meeting 20% of the total food requirement of the World population from the cultivated area of about 222.16 million hectares with a production of 736.98 million tonnes[1]. Recent estimate indicated that world will need around 1090 million tonnes of wheat by 2050 from its current production level. To meet this demand, developing countries should increase their wheat production by 77 per cent and more than 80 per cent of demand should come from vertical expansion (Paroda, et al. 2013).

The major Wheat producing States are Uttar Pradesh, Punjab, Madhya Pradesh, Haryana, Rajasthan, Bihar and Maharashtra. These States contributed more than 88 percent of total wheat production in the country during 2016-17. The area, production and productivity of wheat in Uttar Pradesh during 2016-17 was 9.66 million hectares, 30.06 million tonnes and 3113 kg ha^{-1}[1].

Wheat is staple food of approximately 23 percent population of the world. 20 percent energy is achieved through wheat at global level. Among food grains wheat is the richest source of protein and it stands at second place after pulses. In general wheat contains carbohydrate (70%), protein (12%), lipid (2%), vitamins & minerals (2% each) and crude fibre (2%). Besides staple food for human beings, wheat straw is a good source of feed for a large population of cattle in our country. In addition to house hold uses wheat is consumed in industrial uses in different forms viz., starch, gluten, bran, vitamins, binders and filters, food thickeners, card board etc. (http://en.wikipedia.org/)

With the improvement of crop productivity through the adoption of high-yielding varieties and multiple cropping systems, fertilizer use has become more and more important to increase crops yield and quality. Identification of the critical inputs to enhance the mustard production is need of hour. Apart from improved varieties and judicious irrigation, use of balanced fertilizers is critical for realizing higher yield.

The fact that high yielding varieties of wheat possesses high yield potential is undoubtedly associated with their tendency to consume high dose of nitrogen. But the efficiency of utilization of added nitrogen fertilizer is about 50 to 70 percent, as applied N is subjected to various kinds of lasses in the field, causing for low yield. In order to get maximum benefit from nitrogen use, it should not only be applied in right quantity but also at right time according to the growth stages of the crop. The low nitrogen contents of Indian soils further accentuate this problem. Hence, it requires optimum application of Nitrogen fertilization for the crop of better yield and quality.

Plants need phosphorus for growth, utilization of sugar and starch, photosynthesis, nucleus formation and cell division. Phosphorus compounds are involved in the transfer and storage of energy within plants. Energy from photosynthesis and the metabolism of carbohydrates is stored in phosphate compounds for later use in growth and reproduction. Phosphorus is readily translocated within plants, moving from older to younger tissues as the plant forms cells and develops roots, stems and leaves. Adequate P results in rapid growth and early maturity, which is important in areas where frost is a concern. Frequently, will P enhance the quality of vegetative crop growth. An adequate supply of available P in soil is associated with increased root growth, which means roots can explore more soil for nutrients and moisture. A deficiency of P will slow overall plant growth and delay crop maturity.

To optimize crop nutrition, P must be available to the crop in adequate amounts during the growing season. Plants need P throughout their life cycle, especially during early growth stages for cell division and during maturity stage for seed formation and increase in seed weight. P is mobile in the plant, so it is absorbed during early growth and is later redirected for use in seed formation. Higher P levels. increased the yield and N use efficiency.

In view of the above considerations, present investigation entitled, "Effect of nitrogen and phosphorus fertilization on the growth and yield of wheat (Triticum aestivum L.)" was carried out at Agricultural Research Farm of Raja Balwant Singh College, Bichpuri, Agra during 2018-19 with the following objectives: To work out the suitable dose of nitrogen and phosphorus to maximize the yield of wheat. To assess the interaction effect of nitrogen and phosphorus in wheat crop, if any. To work out the economic feasibility of various treatments tested in terms of gross return, net return (Rs. ha_{-1}) and B/C ratio.

Material and methods

The present Field experiment was conducted at Agricultural Research Farm of Raja Balwant Singh College, Bichpuri Agra, during Rabi season of 2018-19 to evaluate the "Effect of nitrogen and phosphorus fertilization on the growth and yield of wheat (*Triticum aestivum* L.)". The experimental material used, experimental techniques and methodology adopted during the course of investigation have been described in this chapter.

The research farm is situated at about 11 km to the west of Agra on Agra-Bharatpur Road at latitude of 27°2° N and longitude of 77°9' E with an elevation of 163.4 m above the mean sea level. The field at Bichpuri farm having homogenous fertility and uniform textural make up was selected for the field experimentation. This region falls under south-western semi-arid zone of Uttar Pradesh.

The soil of experimental field was Gangetic alluvial with calcareous layer at the depth of about 1.5 m to 2.0 metre and was well drained

To determine the fertility status and other physico chemical properties of soil of experimental area a composite soil sample from 30 cm depth was taken just before layout and was subjected to mechanical and chemical analysis.

Raja Balwant Singh College, Agricultural Research Farm, Bichpuri, Agra (U.P.) has semi-arid, sub tropical climate with extremes of temperature both in summers and winters. The winters (December to January) are severe with minimum temperature at 2°C (in general) and during summers (May to June) temperature often goes up to 46 to 48 °C accompanied with hot and desiccating winds.

The mean annual precipitation around 670 mm (average of last decade) and most part of it received during the months of July, August and September, which is too erratic in distribution and intensity. The unprecedented behaviour of rains caused too much seasonal variations in crops yield.

The experimental field was given a pre-sowing irrigation and at proper tilth two ploughings by tractor were done followed by planking each time. Then field was finally laid out into plots leaving irrigation channels and bunds in between treatments.

The full doses of phosphorus as per treatment and potash (40 kg K_2O ha) were supplied through SSP and MOP, respectively as basal dose at sowing time along with one-third of the nitrogen as per treatment through urea and rest 2/3" nitrogen was applied in two split doses after first and second irrigation by top dressing of urea.

Seed material obtained from Directorate of Wheat Research (DWR), Karnal, Haryana, under All India Coordinated wheat Improvement Project was treated with Agrosan GN @ 2g kg seed. The seeding material of variety HD-2967 was applied @ 120 kg seed ha (on the basis of 1000 seed weight of 38 g) in furrows 18 cm apart at the depth of 4-5 cm with the help of kudali and was covered by light planking.

Results and Discussion

Yield attributes

In case of wheat the main yield contributing characters are length of spike, number of spikelets spike number of grains spike and 1000 grain weight. The variations in these yield attributes due to treatment effect were measured and results so obtained were subjected to statistical analyses. The data pertaining to the main effects of all yield attributes have been summarized in Table-1.

Length of spike

Effect of Nitrogen levels

A critical study of the data presented in Table-1 revealed that nitrogen levels had significant effect on length of spike. The length of spike significantly increased with every higher level of nitrogen level up to 150 kg Nha^{-1}. When the nitrogen level increased from 150 kg N ha to 200 kg N ha^{-2} the difference in length of spike was nominal and could not cross the level of significance. The magnitude of increase in spike length with the application of 150 kg N ha^{-1} (N_3) was to the tune of 31.57 and 12.11 per cent, respectively when compared with N_1(50 kg Nha^{-1}) and N_2 (100 kg N ha^{-1}) levels.

Effect of Phosphorus

The length of spikes affected significantly due to different levels of phosphorus. Phosphorus level 90 kg P_2O_3 ha^{-1} was at par with 60 kg ha^{-1} and both the phosphorus levels had appreciably longer spikes by 32.84 and 12.66 per cent, and 34.00 and 13.64 per cent, respectively over 30 kg P_2O_5 ha^{-1} and control (P_0). The difference in spike length between P_1 and P_0 was not appreciable in this regard.

Table 1 Yield attributing characters as influenced by nitrogen and phosphorus levels

Treatments		Spike length (cm)	No. of spikelets spike^{-1}	No. of grains spike^{-1}	1000 grain weight (g)
Nitrogen levels (kg ha^{-1})					
50	N_1	6.05	30.25	50.03	40.43
100	N_2	7.1	31.33	51.33	41.74
150	N_3	7.96	33.72	53.42	42.09
200	N_4	8.14	34.53	54.19	42.79
SEm ±		0.21	0.43	0.45	0.35
CD at 5%		0.61	1.23	1.29	1.01
Phosphorus level (kg ha^{-1})					
0	P_0	6.03	30.04	50.51	40.46
30	P_1	7.11	32.41	51.35	41.74
60	P_2	8.01	33.67	53.33	42.08
90	P_3	8.08	33.71	53.78	42.77
SEm ±		0.21	0.43	0.45	0.35
CD at 5%		0.61	1.23	1.29	1.01

Number of spikelets spike^{-1}

Effect of Nitrogen levels

From the data presented in Table-1, it is apparent that different levels of nitrogen application exert significant effect of number of spikelets spike^{-1}. Application of 150 kg Nha (Ni) did not differ significantly from N. (200 kg N ha^{-1}) but both the levels produced higher number of spikelets spike^{-1} over N_1 (50 kg N ha^3) and N_2 (100 kg N ha^{-1}) which were statistically at par. The magnitude of increase in number of spikelets spike with 150 kg N ha was to the tune of 11.47 and 7.63 per cent when compared with N_1 (50 kg Nha) and N_2 (100 kg N ha^{-1}), respectively.

Effect of Phosphorus

The data presented in Table-1. clearly indicate that levels of phosphorus had significant effect on number of spikelets $spike^{-1}$. Number of spikelets spike increased with every increase in the levels of phosphorus application up to 90 kg ha, however significantly difference was recorded up to 60 kg P_2O_5 ha^{-1}. The increase in number of spikelets $spike^{-1}$ with 30, 60 and 90 kg P_2O_5 ha^{-1} was to the tune of 7.89, 12.08 and 12.22 per cent, respectively when compared with control (Po).

Number of grains $spike^{-1}$

Effect of Nitrogen levels

Table-1 clearly indicates that application of different nitrogen levels had significant effect on number of grains spike. The number of grains $spike^{-1}$ increased appreciably with every increase in the levels of nitrogen application up to 150 kg N ha^{-1}. Further increase in level of nitrogen increased number of grains spike marginally which could not cross the level of significance. Per cent increase in number of grains $spike^{-1}$ with 150 kg N ha^{-1} was to the tune of 6.78 and 4.07 over 50 and 100 kg N ha^{-1}, respectively.

Effect of Phosphorus

The number of grains spike was affected significantly due to different levels of phosphorus. Phosphorus level 90 kg P_2O_5 ha^{-1} was at par with 60 kg P_2O_5 ha^{-1} and both the phosphorus levels had appreciably more number of grains spike by 5.58 and 3.86 per cent, and 6.47 and 4.73 per cent over 30 kg P_2O_5 ha^{-1} and control (P_0), respectively. The difference in number of grains $spike^{-1}$ between P_1 and P_0 was not appreciable.

1000-Grains weight

Effect of Nitrogen levels

The data set out in Table-1 indicated that levels of nitrogen had significant effect on 1000-grains weight. The 1000 grains weight increased with every increase in the level of nitrogen application. However, the difference in 1000-grains weight due to 150 kg N ha^{-1} (N_3) and 200 kg N ha^{-1} (N_4) levels of nitrogen was nominal and could not reach the level of significance. The magnitude of increase in 1000-grains weight with 150 kg N ha^{-1} (N_3) level was to the tune of 4.11 and 0.84 per cent, respectively over 50 kg N ha^{-1} (N_1) and 100 kg N ha^{-1} (N_2) levels, respectively.

Effect of Phosphorus

The different levels of phosphorus had significant effect on 1000 seed weight. Application of 60 and 90 kg P_2O_5 ha^{-1} did not differ significantly but had significantly higher 1000 seed weight than that of 30 kg P_2O_5 ha^{-1} (P_1) and control (P_0). The differences in 1000 seed weight due to application of 30 kg ha^{-1} (P_1) and control (P_0) was also significant.

Yield (q ha^{-1})

Biological yield (q ha^{-1})

The data on biological yield (q ha^{-1}) of wheat were subjected to statistical analysis. The mean square corresponding to the appropriate components of variance are given in the magnitude of the main effects of levels of nitrogen and phosphorus are summarized in Table-2.

Effect of Nitrogen levels

Biological yield (q ha^{-1}) increased appreciably with increasing levels of nitrogen application up to 150 kg N ha^{-1}. The magnitude of increase in total biological yield with 150 kg N ha^{-1} was to the tune of 9.29 and 4.30 per cent over the 50 and 100 kg N ha^{-1} respectively.

Table 2 Biological, Grain, Straw Yields and harvest index of wheat as influenced by nitrogen and phosphorus levels

Treatments		Biological yield (q ha^{-1})	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
Nitrogen levels (kg ha^{-1})					
50	N_1	96.93	40.01	56.92	41.28
100	N_2	101.56	42.03	59.53	41.38
150	N_3	105.93	45.26	60.67	42.73
200	N_4	107.87	46.48	61.39	43.09
SEm ±		0.87	0.93	0.52	0.36
CD at 5%		2.48	2.64	1.48	1.03
Phosphorus level (kg ha^{-1})					
0	P_0	96.27	40.32	55.95	41.88
30	P_1	103.3	42.86	60.44	41.49
60	P_2	105.63	44.91	60.72	42.52
90	P_3	107.06	45.69	61.37	42.68
SEm ±		0.87	0.93	0.52	0.36
CD at 5%		2.48	2.64	1.48	1.03

Effect of Phosphorus

Total biological yield (q ha^{-1}) was significantly influenced due to application of different levels of phosphorus (Table-2). Application of 90 kg P_2O_5 ha^{-1} (P_1) did not differ significantly with 60 kg P_2O_5 ha^{-1} (P_2) but both the levels significantly produced 2.26, 9.72 and 3.64, 11.21 per cent higher biological yield than that of recorded with 30 kg P_2O_5 ha^{-1} (P_1) and control (P_0), respectively. Increase in biological yield per hectare with the application of 30 kg P_2O_5 ha^{-1} (P_1) was also significant over control (P_0).

Grain yield (q ha^{-1})

Effect of Nitrogen levels

The data computed in Table-2 clearly indicate that the grain yield differed significantly due to levels of nitrogen. Every increase in the nitrogen level increased the grain yield significantly up to 150 kg N ha^{-1}'. The per cent increase in grain yield with the application of 150 kg N ha was to the tune of 13.12 and 7.68 per cent over 50 and 100 kg N ha^{-1}, respectively. When the nitrogen level increased from 150 kg N ha^{-1} to 200 kg N ha^{-1} the grain yield increased marginally by 2.70 per cent and the difference was not significant.

Effect of Phosphorus levels

Significant increase in the grain yield was observed (Table-2) with every increase in the level of phosphorus up to 60 kg P_2O_5 ha^{-1} which was statistically at par with 90 kg P_2O_5 ha The increase in grain yield was 6.30, 11.38 and 13.32 per cent with the application of 30, 60 and 90 kg P_2O_5 ha^{-1} over control, respectively.

Straw yield (q ha^{-1})

Effect of Nitrogen levels

A perusal of data set out in Table-2 showed that levels of nitrogen had significant impact on straw yield. Table further indicate that application of 200 kg N ha^{-1} (N_3) produced the maximum straw and this level of nitrogen was significantly superior as compared to other levels of nitrogen except 150 kg N ha^{-1}. The magnitude of increase in straw yield with the application of 150 kg N ha^{-1} over 50 and 100 kg N ha^{-1} was 6.59 and 1.92 per cent, respectively.

Effect of Phosphorus levels

Data presented in Table-2 revealed that the straw yield differed significantly with the application of phosphorus as compared to control. However, the differences between P_1, P_2 and P_3 could not cross the level of significance.

Harvest index (%)

The data pertaining to harvest index (%) were analyzed statistically and the data for main effect of treatments are summarized in Table-2.

Effect of Nitrogen levels

Different levels of nitrogen application had significant effect on harvest index (Table-2). The highest harvest index was recorded with 200 kg N ha^{-1} (Na) which was statistically at par with 150 kg N ha^{-1} (N_3) and both these levels proved their significant superiority over 50 kg N ha^{-1} (N_1) and 100 kg N ha^{-1} (N_2) levels of nitrogen, which were also statistically at par among themselves.

Effect of Phosphorus levels

Table-2 shows that the highest harvest index was obtained with the application of 90 kg P_2O_5 ha^{-1} which was significantly higher than other levels of phosphorus application except 60 kg P_2O_5 ha^{-1}. However, treatment P_1 (30 kg P_2O_5 ha^{-1} and P_0 (control) were also statistically at par in this respect.

Economic analysis of wheat

The economic feasibility of different agronomic practices is usually a deciding factor for its adoption by the farmers for commercialization of any crop production programme. It is, therefore, of common interest to calculate the effect of different treatments taken in this study on the yield of wheat.

Economic efficiency of various treatments taken in this study was worked out on the basis of net return. The prevailing market rates remained during field experimentation at R.B.S. College, Agricultural research farm, Bichpuri, Agra, were taken in to account for this purpose. Data obtained were summarized in Table-3.

A perusal of data presented in Table-3 reveals that there was considerable impact of various treatments on economics of the factors under study in relation to the other effects on yield and expenditure involved in different levels of nitrogen and phosphorus application in wheat.

The Table-3 under reference shows that the highest net return of Rs. 67263 ha^{-1} was obtained from application of 200 kg N ha^{-1} with 60 kg P_2O_5 ha^{-1} followed by 200 kg N ha^{-1} with 30 kg P_2O_5 ha^{-1} (Rs. 67116 ha^{-1}).

Table 3 Economics of wheat crop (Rs. ha^{-1}) as influenced by nitrogen and phosphorus levels

Treatment	Gross income (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Net income (Rs. ha^{-1})	B C ratio
N_1P_0	92260	30978	61282	2.98
N_1P_1	95362	32665	62697	2.92
N_1P_2	97196	34353	62843	2.83
N_1P_3	98003	36040	61963	2.72
N_2P_0	94535	31673	62862	2.98
N_2P_1	97636	33360	64276	2.93
N_2P_2	99470	35048	64422	2.84
N_2P_3	100277	36735	63542	2.73
N_3P_0	97565	32369	65196	3.01
N_3P_1	100666	34056	66610	2.96
N_3P_2	102500	35744	66756	2.87
N_3P_3	103307	37431	65876	2.76
N_4P_0	98767	33065	65702	2.99
N_4P_1	101868	34752	67116	2.93
N_4P_2	103703	36440	67263	2.85
N_4P_3	104509	38127	66382	2.74

As the benefit over per rupee invested is concern the maximum B:C ratio (3.01) was noted with application of 150 kg N ha^{-1} without phosphorus followed by 200 kg N ha^{-1} without phosphorus (2.99).

Yield Studies

The grain yield being chief economic basis needs special consideration while evaluating treatment effect. The yield of any crop is generally based on two factors *viz*. plant population $unit^{-1}$ area and yield $plant^{-1}$. This hold true for wheat crop too. Further, the yield $plant^{-1}$ is affected by several characters like number of spike plant, length of spike, number and weight of grains spike and 1000 grain weight.

Reference to Table-2 will show that the increasing rates of nitrogen application increased biological yield q ha^{-1} up to 200 kg ha^{-1}, however difference was significant only up to 150 kg N ha^{-1}. Number of shoots per metre row length at harvest increased appreciably with the application of 150 and 150 kg N ha^{-1}. The difference in between 150 and 200 kg N ha^{-1} was not well marked. It may be due to fact that nitrogen by and large, is responsible for the production for new meristematic tissues which, in turn, enhance more number of shoots metre row length. At harvest plant height was appreciably increased with the application of 150 and 200 kg N ha over 50 and 100 kg N ha^{-1}. As discuss earlier, nitrogen, being a structural constituent of proteins, seems to be essential for cell division and cell expansion which are the prime characteristics of dynamics of growth, hence increased plant height. The beneficial effect of 150 or 200 kg N ha application on one or more characters at harvest viz. number of shoots and plant height[4, 5, 6, 8].

In the present study plant population per metre row length and dry matter accumulation in plants of 25 cm row length was significantly improved which may be ascribed to the favourable effect of 150 and 200 kg N ha^{-1} over 50 and 100 kg N ha^{-1}. The better results in plant population and dry matter per 25 cm row length might be held responsible for higher biological yield ha Biological yield ha^{-1} appreciably increased with 150 or 200 kg N ha^{-1} over lower rates of nitrogen[4].

The data assembled in Table 4.6 very well indicate that importance of nitrogen as judged by grain production. It may be seen that the grain yield ha^{-1} with 50, 100,150 and 200 kg N ha^{-1} was 40.01, 42.03, 45.26 and 46.48 q ha^{1}, respectively. The effect of nitrogen fertilization was very well marked with the application of 150 and 200 kg N ha^{-1} which increased reproductive energy and there was an increased in number of effective shoots which formed the set of longer spikes. The more number of effective shoots the greater would be the spike number. Grain weight spike significantly increased with 150 and 200 kg N ha^{-1} over 50 and 100 kg N ha^{-1}. The higher grain yield might be due to increase in protoplasm and consequently the amount of proteins accumulated in grain caused large grain size and thus produced heavy grains in 150 and 200 kg N fertilized plants. Rates of nitrogen application had significant effect on length of spike and number of grains spike increased with increasing rates of nitrogen application up to 150 Kg ha^{-1}. Further, rates of nitrogen application also had significant effect on 1000 grain weight, however, 1000 grain weight increased appreciably with every increase in the rate of nitrogen application up to 150 kg N ha^{-1}.

It is quite clear from such findings that number of longer spikes and grain weight spike were improved with 150 and 200 kg N ha^{-1} over 50 and 100 kg N ha^{-1}. Thus, these yield attributes might have resulted in significantly higher grain yield plant which, in turn, may be responsible for higher grain ha^{-1} with 150 and 200 kg N ha^{-1}. Dry matter production ha^{-1}, straw yield ha^{-1} increased with every increase in the rate of nitrogen application up to 200 kg ha^{-1} however significant difference was noticed only up to 150 kg ha^{-1}. Better plant growth in terms of number of shoots, plant height and dry matter accumulation in plants of 25 cm row length might be help responsible for higher straw yield ha^{-1}. The rates of nitrogen application also had significant effect on harvest index, the highest harvest index was recorded with the 200 kg N ha^{-1} closely followed by 150 kg N ha^{-1}[2, 6, 7, 9].

The application of phosphorus to wheat had a significant effect on yield attributes viz. length of spike, grains spike and 1,000 grain weight and grain, straw and biological yield. Application of phosphorus both at 60 and 90 kg P_2O_5 ha^{-1} to wheat improved yield attributes and yields over no phosphorus and 30 kg P_2O_5 ha^{-1}. This might be possibly due to continued and balanced supply of nutrients enhancing their availability for their active involvement in shoot and root growth, which finally translated into higher yield attributes and yields of wheat.

Investigation entitled "Effect of nitrogen and phosphorus fertilization on the growth and yield of wheat (*Triticum aestivum* L.)" was carried out in Rabi season of 2018-19 at RBS Collage Agricultural Research Farm, Bichpuri, Agra. The variables involved in this study were four levels of nitrogen (50,100,150 and 200 kg N ha^{-1}) and four levels of phosphorus (0,30,60 and 90 kg P_2O_5 ha^{-1}). Thus, in all 16 treatment combinations were compared in a 'Randomized block design' with four replications. The soil of the experimental field was sandy loam in texture with a pH 7.84. The soil was deficient in available nitrogen (174.40 kg ha^{-1}) and medium in available phosphorus (25.80 kg P_2O_5 ha^{-1}) and available potash (220.70 kg K_2O ha^{-1}).

Salient findings emerging out of the field experiment are presented in preceding chapters are summarized as follows:

Effect of levels of Nitrogen

1. Length of spikes significantly increased with every higher level of nitrogen level up to 150 kg N ha^{-1}.
2. Number of spikelets spike^{-1} were conspicuously increased with every increase in the level of nitrogen up to 150 kg N ha^{-1}.
3. The number of grains spike increased appreciably with every increase in the levels of nitrogen application up to 150 kg N ha^{-1}.
4. 1000-grains weight with 150 kg N hat was higher by 4.11 and 0.84 per cent, respectively over 50 and 100 kg N ha^{-1}, respectively.
5. Biological yield (q ha^{1}) increased appreciably with every increase in the levels of nitrogen up to 150 kg N ha^{-1} and the magnitude of increase was 9.29 and 4.30 per cent over the 50 and 100 kg N ha^{-1}, respectively.
6. Grain yield was conspicuously higher with the application of 150 kg N ha^{-1} by 13.12 and 7.68 per cent over 50 and 100 kg N ha, respectively, however, grain yield increased marginally when nitrogen rate was increased from 150 to 200 kg N ha^{-1}.
7. Appreciably higher straw yield was obtained with the application of 150 kg N ha^{-1}.
8. The highest harvest index was recorded with 200 kg N ha which was significantly higher than 50 and 100 kg N ha^{-1}.

Effect of level of Phosphorus

1. Length of spike, number of spikelets spike^{-1} number of grains spike^{-1} and 1000 grain weight had significantly higher values with the application of 60 kg P_2O_5 ha^{-1} than that of 30 kg P_2O_5 ha^{-1} and control.
2. Biological yield increased significantly with increasing levels of phosphorus up to 60 kg P_2O_5 ha and the increase was 2.26 and 9.72 per cent over 30 kg P_2O_5 ha^{-1} and control, respectively.
3. Grain yield also increased conspicuously with every increase in the level of phosphorus application up to 60 kg P_2O_5 ha^{-1}.
4. Appreciably higher straw yield was obtained with the application of 60 kg P_2O_5 ha^{-1}.
5. The highest harvest index was obtained with the application of 90 kg P_2O_5 ha^{-1} which was significantly higher than other levels of phosphorus application except 60 kg P_2O_5 ha^{-1}.

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