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Optimizing Nitrogen and Phosphorus Inputs for Enhanced Growth and Yield Performance of Oat (*Avena sativa* L.)

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ABSTRACT

A field experiment was carried out during the rabi season of 2015–16 at the Agricultural Research Farm, R.B.S. College, Bichpuri (Agra), to evaluate the influence of varying nitrogen and phosphorus levels on the growth, yield, and yield components of oat (Avena sativa L.). The experiment followed a factorial randomized block design comprising four nitrogen levels (0, 80, 100, and 120 kg ha^{-1}) and three phosphorus levels (0, 40, and 80 kg ha^{-1}). Results indicated that nitrogen application significantly enhanced plant height, number of tillers per plant, number of ears per plant, ear length, grains per ear, grain yield, and straw yield. The highest nitrogen dose (120 kg ha^{-1}) recorded the maximum values for all growth and yield parameters, showing notable improvements over the control. Similarly, phosphorus application at 80 kg ha^{-1} significantly improved these parameters compared to untreated plots. Grain and straw yield increases due to nitrogen application (80, 100, and 120 kg ha^{-1}) were 18.63%, 27.25%, and 34.53%, and 16.55%, 22.57%, and 30.04%, respectively, over control. Phosphorus application at 40 and 80 kg ha^{-1} resulted in grain yield increases of 3.28% and 8.29%, and straw yield increases of 3.12% and 7.81%, respectively. These findings suggest that integrated application of 120 kg N ha^{-1} and 80 kg P ha^{-1} optimizes oat productivity under agro-climatic conditions of Agra.

Keywords: *Nitrogen, phosphorus, yield, yield attribute*

Introduction

Oat (*Avena sativa* L.) is one of the most important *rabi* fodder crops cultivated across various agro-climatic zones in India. It thrives best under cool and moist conditions, particularly during key growth stages such as germination, tillering, booting, and heading. Loamy soils are most suitable for its optimal growth, and the crop is extensively cultivated in states such as Punjab, Haryana, Uttar Pradesh, Maharashtra, Odisha, Bihar, West Bengal, and Gujarat. Among the cultivated species, *Avena sativa* accounts for nearly 80% of the global oat acreage, followed by *Avena byzantina*, with minor areas under other species. Oat is highly valued for its multipurpose utility—it is used as green fodder, hay, straw, or silage. Moreover, oat grain serves as a nutritionally balanced concentrate for poultry, cattle, sheep, and other livestock.

On a dry matter basis, oat harvested at the milk stage contains approximately 6.44% crude protein, 28.72% crude fibre, and 53.20% nitrogen-free extract. It also contains 2.31% ether extract, 9.33% total ash, 0.47% calcium, 0.22% phosphorus, 0.22% magnesium, 0.52% sodium, and 2.84% potassium [1]. Oats are considered one of the most nutritious cereal grains, with higher protein and fibre content compared to many other cereals. The protein content of rolled oats is particularly notable. Since most oat-based food products utilize the whole grain, they retain essential nutrients found in the bran and germ. In India, oats demonstrate wide adaptability, especially in the western and north-western regions, due to their rapid regrowth capacity and superior nutritional profile [2].

Importance of Nitrogen and Phosphorus

Nitrogen is a critical macronutrient that contributes to the lush green coloration of crops by promoting chlorophyll synthesis. In arid and semi-arid regions, nitrogen deficiency is a common challenge due to low organic matter content in the soil, which serves as the primary reservoir of nitrogen. Even when present, organic matter decomposes rapidly under such climatic conditions [3].

Phosphorus is another essential nutrient that plays a vital role in early root development, tillering, leaf expansion, and ultimately in flowering and grain formation. It is a structural component of nucleic acids and vital coenzymes such as NAD, NADP, and ATP. Phosphorus is indispensable for energy transfer, cell division, and seed and fruit development, making it a key factor in crop productivity.

Materials and Methods

A field experiment was conducted during the *Rabi* season of 2015–16 at the Agricultural Research Farm, R.B.S. College, Bichpuri, Agra (Uttar Pradesh), India. The experimental site is situated in a semi-arid region characterized by extreme temperatures—ranging from 45°C to 48°C during summer and dropping to as low as 2°C in winter. The region receives an average annual rainfall of approximately 650 mm, predominantly during the monsoon months from June to September. The soil at the experimental site was sandy loam in texture, with the following initial properties: electrical conductivity (EC) of 1.8 dS m^{-1}, pH 7.9, organic carbon content of 3.6 g kg^{-1}, and available nitrogen (N), phosphorus (P), and

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potassium (K) at 181.0, 28.6, and 292.0 kg ha^{-1}, respectively.

The experiment was laid out in a factorial randomized block design (FRBD) with three replications. The treatment consisted of four nitrogen levels (0, 80, 100, and 120 kg N ha^{-1}) and three phosphorus levels (0, 40, and 80 kg P_2O_5 ha^{-1}). A uniform potassium dose of 40 kg K_2O ha^{-1} was applied across all treatments. Urea, single super phosphate (SSP), and muriate of potash (MOP) served as the sources of nitrogen, phosphorus, and potassium, respectively. Half of the nitrogen and the full doses of phosphorus and potassium were applied as basal at the time of sowing. The remaining nitrogen was top-dressed in two equal splits at critical growth stages. The oat crop was sown in the second week of November using certified seeds at the rate of 100 kg ha^{-1}. Standard agronomic practices were followed throughout the cropping period. The crop was harvested at physiological maturity. Observations were recorded on various growth parameters and yield attributes, and data on grain and straw yields were collected for analysis.

Results and Discussion

Plant height

The data regarding effect of N and P application on plant height (cm) of oat are presented in Table 1. Application of N and P has significant effect on the plant height of oat. All the levels of N application increased significantly the plant height of oat (cm) over control. Further, it is noted that higher dose of nitrogen N_3 (N@120 kg ha^{-1}) application caused maximum plant height over all the other levels of nitrogen application. The response of oat to application of N was also reported by [4, 5,6]. The data given in Table-1 clearly indicate that as far as the plant height is concerned the response of oat crop to phosphorus was also significantly positive. The maximum plant height (cm) obtained at higher level of phosphorus P_2 (P@ 80 kg ha^{-1}). The response of oat to application of P was also reported by [7,8,9,].

Number of tillers plant^{-1}

The data on the effect of nitrogen and phosphorus application of number of tillers of oat crop are presented in table-1. The maximum number of tillers per plant was noted with the application of 120 kg N ha^{-1} (N_3) which was significantly higher over control and N_1 but the increase in number of tillers due to the application N_3 was mathematically higher but statistically at par as compared to N_2 level of N application. Similar results were reported by [10, 11, 6] in this regard. The data regarding number of tillers as affected by application of phosphorus as depicted in table-1 clearly show that the number of tillers increased significantly due to the application of P to oat crop. The maximum number of tillers per plant was noted with the application of 80 kg P ha^{-1} (P_2). The significant response of P to oat crop was also reported by [8, 12]

Number of ears per plant

The data on number of ears per plant of oat as affected by levels of nitrogen and phosphorus are presented in table-1. The maximum number of ears per plant of oat crop was recorded under N_3 @ (120 kg N ha^{-1}) compared to control respectively. The increase in number of ears per plant was in accordance with the findings of [11, 13, 14]. The data (table -1) clearly indicate that P application had a significant positive effect on number of ears per plant of oat crop. The application of P @ 80 kg ha^{-1} gave significantly higher number of ears per plant over control. The similar results were reported by [15, 11, 8].

Ear length

The data regarding ear length (cm) is given in table-1 the clearly showed that nitrogen application increased ear length (cm) significantly over control. However, the application of higher level of nitrogen (N_3) in this study increased the ear length (cm) significantly over control. The significant effect of nitrogen on ear length was also reported by [16, 17]. The application of phosphorus @ 80 kg ha^{-1} (P_2) recorded with maximum length of ear in this study. However, P_2 level of phosphorus application of affected significantly over control. The similar results were also reported by [15, 11, 8].

Number of grains per ear

A perusal of the data presented in table-1 also clears that all the levels of N application increased the number of grains per ear significantly and higher level N_3 maintained its superiority in this regard. The significant response of N application was also reported by [5, 18, 9]. It is also evident from the table-1 that application of phosphorus to the oat crop also increased number of grains per ear significantly over control. The higher number of grains per ear was recorded with the P_2 level of phosphorus application. The application of P and its effects were also reported by [5]

Grain Yield

An analysis of Table 1 indicates that the minimum grain yield (q ha^{-1}) of oat was recorded under the control treatment, likely due to the inherently low fertility status of the experimental soil. The application of nitrogen significantly enhanced grain yield compared to the control. The recorded yield increase due to nitrogen application at 80, 100, and 120 kg N ha^{-1} was 18.63%, 27.25%, and 34.53%, respectively, over the control. This improvement can be attributed to the enhanced availability of nitrogen, which is critical for chlorophyll formation and vegetative growth, ultimately leading to improved yield attributes. These findings are consistent with previous studies [5, 9, 18]. Similarly, phosphorus application also exerted a significant effect on grain yield. The application of 40 and 80 kg P_2O_5 ha^{-1} resulted in grain yield increases of 3.28% and 8.29%, respectively, compared to the control. This positive response can be ascribed to the role of phosphorus in root development, energy transfer, and reproductive growth, all of which contribute to improved yield performance.

Straw Yield

As illustrated in Table 1, the application of nitrogen significantly enhanced straw yield (q ha^{-1}) of oat over the control. The highest straw yield was observed with the application of 120 kg N ha^{-1} (N_3), while the lowest yield was recorded under the control treatment, highlighting the essential role of nitrogen in biomass accumulation. Nitrogen promotes vegetative growth, and its adequate availability contributes to increased plant height and tillering, ultimately leading to higher straw yield. The increase in straw yield due to the application of 80, 100, and 120 kg N ha^{-1} was 16.55%, 22.57%, and 30.04%, respectively, over the control. These findings align with the results reported by [6]. Phosphorus application also positively influenced straw yield. All phosphorus levels significantly improved straw yield compared to the control, with the highest response observed at 80 kg P_2O_5 ha^{-1} (P_2). The increase in straw yield due to 40 and 80 kg P ha^{-1} was 3.12% and 7.81%, respectively, over the control. The improvement in straw yield with phosphorus application can be attributed to enhanced root development and overall plant vigor, which supported better nutrient uptake and biomass production. These findings are consistent with earlier reports by [1, 9].

Table1: Effect of nitrogen and phosphorus application on plant height no. of tillers plant-1, no. of ears plant-1, ear length, no. of grains ear-1, grain yield and straw yield of oat crop

Treatments	Plant height (cm)	No. of tillers plant^{-1}	No. of ears plant^{-1}	ear length	No. of grains ear^{-1}	grain yield (q ha^{-1})	straw yield (q ha^{-1})
Nitrogen levels							
N_0	80.61	41.22	28.44	30.65	32.22	48.02	88.32
N_1	106.93	42.55	30.11	31.57	35.44	56.97	102.94
N_2	109.78	43.67	31.22	32.11	37.22	61.10	108.26
N_3	113.22	44.89	33.89	33.92	39.22	64.60	114.85
SEM ±	1.210	0.460	0.400	0.410	0.42	0.79	0.890
CD (P=0.05)	2.078	0.790	0.687	0.704	0.724	1.356	1.528
Phosphorus levels							
P_0	98.20	41.25	27.00	31.42	35.00	55.53	99.88
P_1	102.73	43.67	32.17	32.14	35.92	57.35	103.21
P_2	106.98	44.33	33.58	32.63	37.17	60.14	107.69
SEm ±	0.908	0.345	0.300	0.308	0.315	0.593	0.668
CD (P=0.05)	1.558	0.592	0.515	0.5284	0.541	1.017	1.146

Conclusion

Based on the findings of the present study, it can be concluded that the growth, yield, and yield attributes of oat (*Avena sativa* L.) were significantly influenced by the combined application of nitrogen and phosphorus. Among the various treatment combinations, the application of 120 kg N ha^{-1} and 80 kg P ha^{-1} recorded the highest values for plant height, number of tillers per plant, number of ears per plant, ear length, grains per ear, grain yield, and straw yield. The improvement in crop performance may be attributed to the enhanced availability of nutrients, improved root development, and better physiological activity under optimum nutrient supply. The synergistic effect of nitrogen and phosphorus not only promoted vegetative growth but also contributed to greater reproductive output, leading to higher total biomass and grain yield. Therefore, the combined application of nitrogen at 120 kg ha^{-1} and phosphorus at 80 kg ha^{-1} can be recommended for maximizing the productivity of oat under similar agro-climatic conditions.

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