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IMPACT OF ROCK PHOSPHATE AND GYPSUM ON GROWTH AND YIELD OF WHEAT (*Triticum aestivum* L.)

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ABSTRACT

Wheat (*Triticum aestivum* L.) is the 2nd major cereal crop following rice. It has significant importance in the production of food security. The effects of rock phosphate, gypsum and Azotobacter on wheat crop yield characteristics, growth and productivity were studied through field investigations carried out during the rabi season. This experiment was conducted using a randomised block design. In this instance, different combinations of gypsum (160–200 kg ha^{-1}), rock phosphate (180–260 kg ha^{-1}) and Azotobacter inoculation were used. Every treatment received the same application of various common agronomic techniques. Plant height, the number of tillers $plant^{-1}$, spike length, yield characteristics and yield were all recorded at different stages of growth. The data was then statistically analysed using the ANOVA method. Plant height (33.86, 65.96 and 101.55 cm), number of tillers plant-1 (6.03, 8.26, and 11.46), and spike length (13.36 cm) were all significantly greater in Treatment T_8 (rock phosphate 260 kg ha^{-1} + gypsum 200 kg ha^{-1} + Azotobacter) at 30, 60 and 90 days after sowing. Weight of 1000 grains (44.33 g), number of spikelets $spike^{-1}$ (19.93), and number of grains $spike^{-1}$ (67.80) were all considerably improved under the current treatment. Treatment T_8 produced the highest grain yield (61.03 q ha^{-1}), biological yield (224.48 q ha^{-1}) and harvest index (28.53%), while treatments T_1 (Rock phosphate 180 kg ha^{-1} + Azotobactor) and T_4 (Gypsum 160 kg ha^{-1} + Azotobactor) showed comparatively subpar outcomes. Based on the aforementioned findings, phosphorus is improved, when rock phosphate, gypsum and Azotobacter are used together.

Key words : Wheat, Yield attributes, Harvest index, Biological yield.

Introduction

Wheat (*Triticum aestivum* L.) ranks second to rice in terms of importance and is essential in ensuring food security at national and international levels. In India, wheat covers an area of around 31.2 million ha and produces 95.9 million tonnes annually, giving an average yield of 3.07 tonnes ha^{-1} (Chaudhary 2017). The crop is considered a long day plant with a C_3 photosynthetic pathway. Optimal growth occurs in regions with cool and wet weather at an optimal soil pH ranging between 6.5 and 7.5. Nutritious value-wise, 100 grams of wheat provides 71 grams of carbohydrates, 12.6 grams of protein and 12.2 grams of dietary fiber (Khan *et al*., 2017). Wheat growing states are mainly Uttar Pradesh, Punjab and Haryana, with more productive regions being those of Punjab and Haryana. Phosphorus (P) is an important element that plays a role in vital biochemical activities including energy transport, formation of nucleic acids, and root growth, hence impacting crop productivity (Khan *et al*., 2017). The basis of terrestrial life on Earth is soil, which is an essential part of the ecosystem (Kushwaha and Chaubey, 2026). Phosphorus plays a vital role in crop growth and development. It directly influences root proliferation, straw strength, grain formation, crop

maturity, and overall crop quality (Katiyar *et al.* 2024). Proper phosphorus management can enhance yield, plant development and crop productivity. Phosphorus is the second most important nutrient given to the soil (Katiyar *et al*., 2024). Rock phosphate (RP) is a naturally occurring source of phosphorus and economically cheaper compared to other sources like soluble fertilizers, especially in soils susceptible to P fixation and leaching losses (Arfan-ul-Haq *et al*., 2021). In addition, RP is used as a feedstock in manufacturing phosphatic fertilizers (Gurdeep and Reddy, 2015). Nevertheless, the use of RP requires certain conditions for maximum efficiency. Gypsum is a source of calcium and sulfur that can improve soil properties through increased water infiltration, reduce erosion, and address soil limitations like aluminum toxicity (Rasouli *et al*., 2013; De *et al*., 2020). It also impacts the pH of the soil and its nutrient content, which affects the activities of microorganisms and the performance of crops (Satyavir *et al*., 2025). Bio-fertilizers can be highly useful in fixing atmospheric nitrogen since they enhance and boost soil fertility (Kapat *et al*., 2024). Combining RP with Gypsum and bio-fertilizers such as Azotobacter makes nutrients and P more accessible in the soil, improving crop production and increasing total land productivity by 15–35%, improving soil organic carbon from 0.8% to 1.3% and improving water retention. Estimates of carbon sequestration rates ranged from 4.2 to 6.8 CO2 t ha^{-1} yr^{-1} (Pratap and Kushwaha, 2026).

Materials and Methods

The study title "Impact of Rock Phosphate and Gypsum on Growth and Yield of Wheat (*Triticum aestivum* L.)" was performed during the *Rabi* period of 2021–22 in the Karguanaji Organic Research Farm at Bundelkhand University's Institute of Agricultural Sciences in Jhansi, Uttar Pradesh. With an elevation of 271 meters above mean sea level and geographic coordinates of 25°27′ 34′ N latitude and 78°36′ 35′ E longitude, the research area has a semi-arid subtropical climate. This location receives around 800 mm of precipitation annually, out of which about 80% occurs during July to September (Meena *et al*., 2019). Maximum temperature during the crop period varied between 31.6°C and 4.2°C, with rainfall accumulation amounting to 8.2 mm during that period. A randomised block design was used to set up the experiment with three replications (Kushwaha *et al*., 2024). Under excellent field circumstances, the foundation seed of wheat variety HI-1544 was acquired from Bundelkhand University and sown in lines at an inter-row distance of 22.5 cm × 10 cm. Five plants per plot were measured for plant height, number of tillers $plant^{-1}$ and other physiological characteristics at intervals of 30, 60, and 90 days after planting (DAP) and during the harvest stage. Spike length, spikelets $spike^{-1}$, grains $spike^{-1}$, weight of 1000 grains, grain yield, biological yield, and harvest index were among the yield parameters identified. At harvest, representative samples of grain and straw were gathered in order to measure the quantities of nitrogen, phosphate, and potassium using accepted analytical techniques.

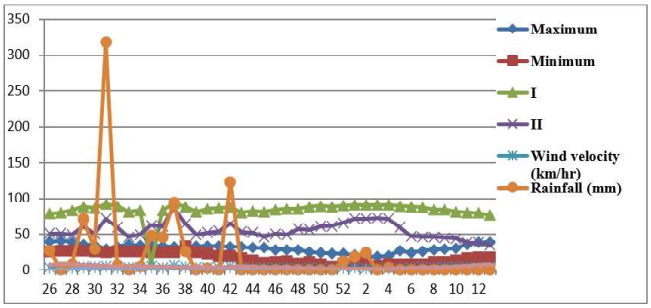


Fig. 1 : Graphical representation of meteorological parameters recorded during the crop growth period.

The data was statistically analysed using Ronald A. Fisher's (1958) analysis of variance (ANOVA) approach, which is appropriate for a randomised block design. The "F" test was used to determine whether treatment effects were significant at the 5% probability level. The critical difference (CD) at P=0.05 was used to compare the treatment averages when the "F" test was deemed significant. For statistical analysis, OP-STAT software was utilised.

Results and Discussion

The use of rock phosphate, gypsum, and Azotobacter had a significant impact on wheat growth, yield characteristics, and production. Plant height at 30 DAS, 60 DAS, 90 DAS (33.86, 65.96 and 101.55 cm), tillers $plant^{-1}$ (6.03, 8.26 and 11.46) and spike length (13.36 cm) were all substantially larger in Treatment T_8 (Rock phosphate 260 kg ha^{-1} + gypsum 200 kg ha^{-1} + Azotobacter). The increase in growth characteristics can be explained by the availability of phosphorus and nutrient intake, which lead to cell division and elongation (Singh *et al*., 2022; Rahman *et al*., 2024). Sharma *et al.* (2012) found similar results, noting enhanced tillering as a result of increased phosphorus availability.

Additionally, several treatments had a considerable impact on yield qualities (Fig. 2). T_1 had the highest test weight (44.33 g), grains $spike^{-1}$ (67.80) and number of spikelets $spike^{-1}$ (19.93), whereas T_1 and T_4 treatments had the lowest results. Increased of phosphorus solubilisation through rock phosphate in the presence of gypsum have availability to improve the nutrient availability and grain filling, which could account for the improvement

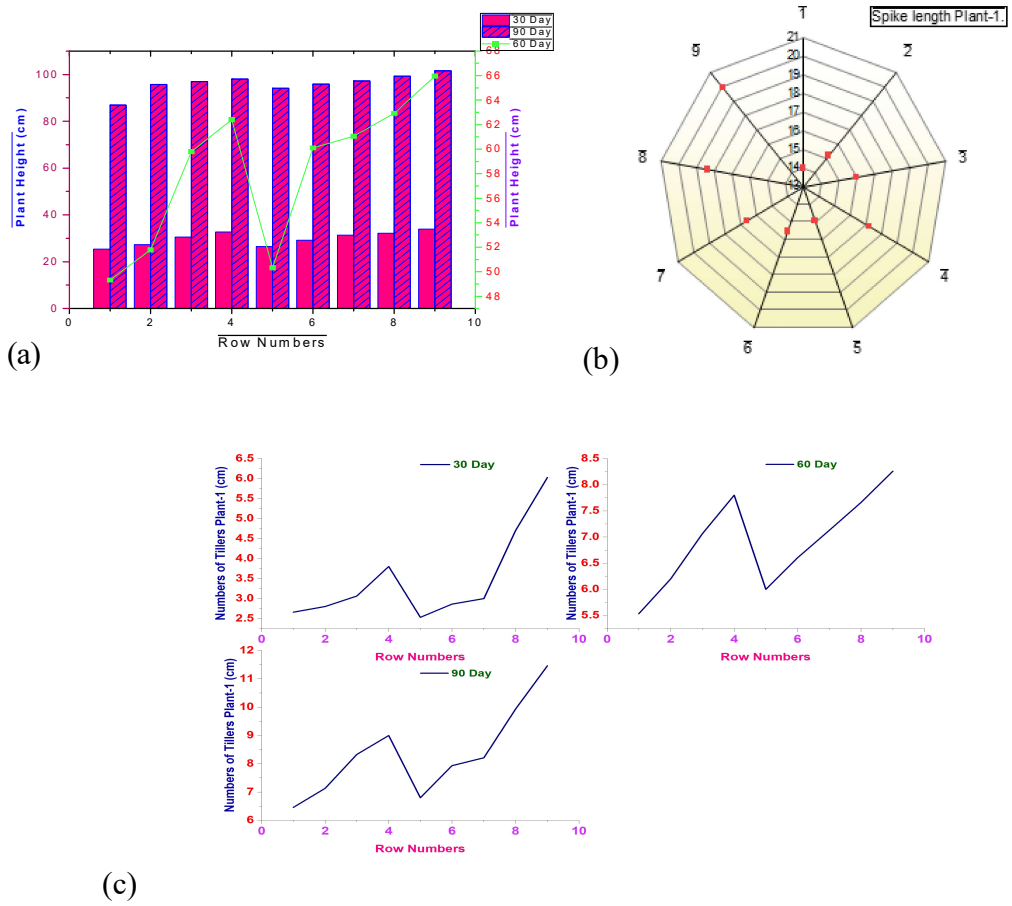


Fig. 2 : (a) Treatment effects on wheat plant height, tiller count, and spike length; (b) spike length; and (c) tiller count per plant at 30, 60 and 90 DAS.

in reproductive indices (Chaudhary *et al.,* 2015; Kumar *et al*., 2019; Pratap and Kushwaha, 2026).

Grain productivity, biological yield, and harvest index were all significantly impacted by treatments. Rock phosphate enhances the production, seed formation, shining of seed and grain quality (Satyavir *et al.* 2025). T_1 had the highest harvest index (28.53%), biological yield (224.48 q ha^{-1}), and grain yield (61.03 q ha^{-1}), whereas T_4 had the lowest values. The increased physical characteristics of the soil and the availability of nutrients, particularly P, Ca and S, can be linked to the increased output. This contributed to the improvement of root development, nutrient absorption and distribution of photosynthetic products (Kumar *et al*., 2019). The combination of rock phosphate and gypsum lead to an improvement in the solubility and efficiency of utilization of phosphorus. Overall, integrated nutrient management using rock phosphate, gypsum, and Azotobacter proved effective in enhancing growth & productivity of wheat under semi-arid conditions.

The correlation coefficients between biological yield, grain yield (q ha^{-1}), test weight, number of spikelets spike^{-1}, and spike length plant^{-1} were estimated by analysing the collected data (Fig. 5). Grain yield and biological yield (0.969), test weight (0.913), spike length plant^{-1} (0.855), and number of spikelets spike^{-1} (0.884) all showed strong positive associations. Test weight (0.910), spike length plant^{-1} (0.924) and number of spikelets spike^{-1} (0.955) all showed favourable correlations with biological yield. Test weight and the number of spikelets spike^{-1} (0.878) and spike length plant^{-1} (0.839) showed positive associations. Additionally, a strong

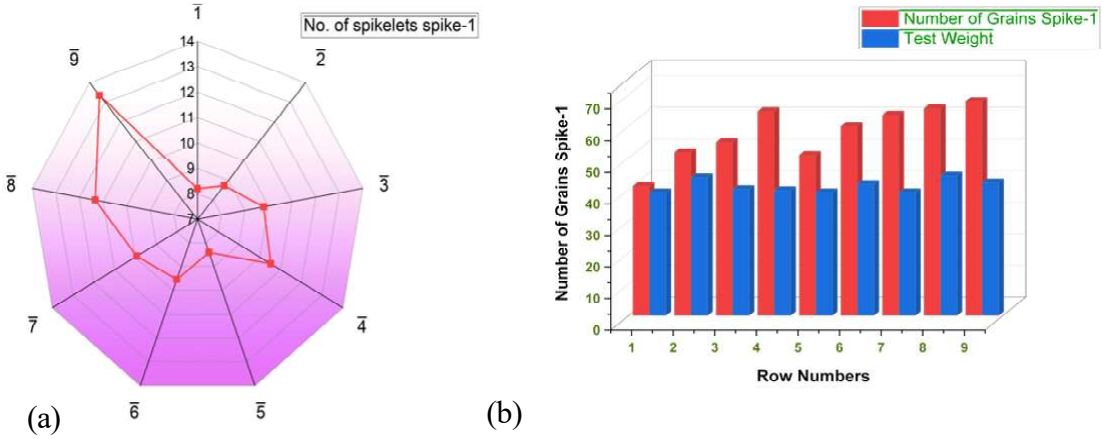


Fig. 3 : (a) Treatment effects on the quantity of spikelets spike^{-1} (b) Wheat test weight and number of grains spike^{-1}.

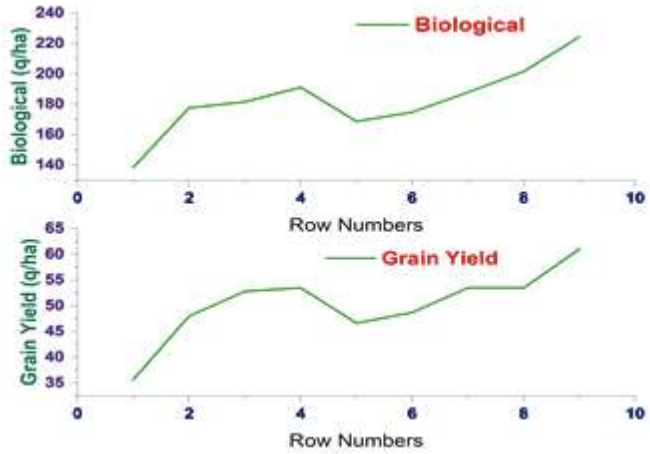


Fig. 4 : Treatment effects on wheat's biological production (q ha^{-1}) and grain yield (q ha^{-1}).

link between the number of spikelets per spike and the length of spikes per plant was discovered (0.984).

Plant heights at various stages (30 DAS, 60 DAS, and 90 DAS), the number of tillers per plant and the harvest index are all positive correlated with each other (Fig. 6). The trait of height of plants at 30 DAS is positively related to height at 60 DAS ($r \approx 0.96$) and is very much associated with tillers at 60 DAS ($r \approx 0.99$), which indicates the importance of initial growth for further development. As in the case of tillers at different ages, there exists a high relation between them, particularly between 60 and 90 DAS ($r \approx 0.95$). Harvest index correlates moderately to highly with other traits, which implies its dependency on the growth factors. Given that almost all the correlation coefficients are larger than 0.70, it can be assumed that all the relationships are significant at $p < 0.01$.

Harvest index was influenced by different treatments (Table 1). The control (T_0 : RDF) recorded a harvest

Table 1 : Different growth parameter data found during the experiment.

Treatments	Harvest Index (%)
T_0 – RDF	27.09
T_1 - Rock phosphate 180 kg/ha. + Azotobactor	26.78
T_2 - Rock phosphate 220 kg/ha. + Azotobactor	27.20
T_3 - Rock phosphate 260 kg/ha. + Azotobactor	27.35
T_4 - Gypsum 160 kg/ha. + Azotobactor	27.20
T_5 - Gypsum 180 kg/ha. + Azotobactor	26.23
T_6 - Gypsum 200 kg/ha. + Azotobactor	26.73
T_7 - Rock phosphate180 kg/ha. + Gypsum 160 kg/ha. + Azotobactor	28.10
T_8 - Rock phosphate 260 kg/ha. + Gypsum 200 kg/ha. + Azotobactor	28.53

	Biological yield	Grain Yield (q/ha)	Test Weight	No. of Spikelet's/spike	Spike length/Plant
Biological yield	1				
Grain Yield (q/ha)	0.969376469	1			
Test Weight	0.909738649	0.912544548	1		
No. of Spikelet's/spike	0.954956765	0.884067684	0.878416073	1	
Spike length/Plant	0.923569194	0.85519546	0.839139979	0.984073729	1

Fig. 5 : The correlation matrix shows strong positive connections between biological yield, grain yield, test weight, spikelets per spike, and spike length, indicating that these traits all contribute to increased crop productivity. Correlations are very high (mostly above 0.80–0.95), they are likely significant at the 1% level ($p < 0.01$) in most biological studies.

	Plant High 30	Plant High 60	Plant High 90	No. of Tillers/Plant 30	No. of Tillers/Plant 60	No. of Tillers/Plant 90	Harvest Index
Plant High 30	1						
Plant High 60	0.96366589	1					
Plant High 90	0.844081949	0.8007607	1				
No. of Tillers/Plant 30	0.766835879	0.711015058	0.614020119	1			
No. of Tillers/Plant 60	0.992252749	0.938598704	0.861188207	0.808417947	1		
No. of Tillers/Plant 90	0.940933531	0.921586126	0.813659094	0.917320266	0.954541914	1	
Harvest Index	0.715487602	0.672589967	0.576194417	0.749730149	0.69064125	0.767658467	1

Fig. 6 : Plant heights, the number of tiller, and the harvest index at different phases of development were found to have strong positive connections and significant relationships.

index of 27.09%. Among individual treatments, T_3 (rock phosphate 260 kg ha^{-1} + *Azotobacter*) recorded a relatively higher value (27.35%), whereas T_5 (gypsum 180 kg ha^{-1} + *Azotobacter*) recorded the lowest (26.23%). The combined application of inputs performed better, with T_7 (rock phosphate 180 kg ha^{-1} + gypsum 160 kg ha^{-1} + *Azotobacter*) and T_8 (rock phosphate 260 kg ha^{-1} + gypsum 200 kg ha^{-1} + *Azotobacter*) recording higher harvest index values of 28.10% and 28.53%, respectively, indicating improved efficiency of assimilate partitioning.

Conclusion

The combined application of rock phosphate (260 kg ha^{-1}), gypsum (200 kg ha^{-1}) and Azotobacter (T_8) significantly improved growth, yield attributes and productivity of wheat. This treatment recorded the highest plant height, tillers, spike length, yield parameters and harvest index over other treatments. This could be because of better nutrient availability and uptake by integrating nutrients into the system. Thus, combined use of rock phosphate, gypsum and Azotobacter can be recommended for higher wheat productivity and sustainable nutrient management under similar conditions.

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