



Effect of Graded Phosphorus Levels on Productivity and Nutrient Dynamics of Wheat

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Abstract

A field experiment was conducted during the rabi season of 2023–24 at the Soil Research Farm, Department of Soil Science, CCS Haryana Agricultural University, to evaluate the response of wheat variety WH 1270 to graded phosphorus levels and associated nutrient dynamics. The experiment was laid out in a Randomised Block Design with three replications and a plot size of 6 m × 6 m. Eleven treatments were evaluated: control, 100% recommended dose of fertiliser (RDF), 125% RDF, 150% RDF, 175% RDF, 125% P + NK, 150% P + NK, 175% P + NK, 125% NP + K, 150% NP + K and 175% NP + K. Grain and straw yields were recorded at maturity, and representative grain and straw samples were analysed for phosphorus and potassium contents using standard laboratory procedures. The control treatment recorded the lowest grain yield (34.23 q ha⁻¹) and straw yield (49.81 q ha⁻¹), whereas 175% RDF produced the highest grain yield (51.93 q ha⁻¹) and straw yield (75.80 q ha⁻¹). Phosphorus and potassium contents in grain and straw also increased with higher phosphorus application. The highest phosphorus content in grain (0.51%) and straw (0.22%), and potassium

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content in grain (0.47%) and straw (1.36%), were recorded under 175% RDF. Treatments receiving higher phosphorus with NK or NP + K improved yield and nutrient content compared with the control, although their performance was generally lower than the corresponding RDF treatment. The results indicate that WH 1270 responded positively to increased and balanced phosphorus fertilisation under the experimental conditions, suggesting the need to reassess phosphorus recommendations for this newly released wheat variety.

Keywords: Wheat; *Triticum aestivum* L.; phosphorus fertilisation; graded phosphorus; recommended dose of fertiliser; grain yield; straw yield; nutrient dynamics; phosphorus content; potassium content; WH 1270.

1. Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops and serves as a staple food for a large proportion of the world's population. In India, wheat occupies a prominent position in the agricultural economy and contributes significantly to food security. Achieving higher wheat productivity requires balanced and efficient nutrient management, among which phosphorus plays a crucial role (Marschner, 2012). Phosphorus is an essential macronutrient involved in energy transfer, cell division, photosynthesis, root development and grain formation. Adequate phosphorus nutrition enhances crop growth, improves nutrient uptake and ultimately increases yield and produce quality (Weil & Brady, 2016).

Recent field evidence indicates that phosphorus applied in combination with zinc significantly improves wheat grain and straw yields, nutrient uptake and post-harvest soil phosphorus status, reinforcing the need for site-specific phosphorus management in wheat (Malav et al., 2025).

In many intensively cultivated soils, phosphorus availability becomes a limiting factor because of continuous nutrient removal by high-yielding crop varieties and fixation of applied phosphorus in soil. Newly released high-yielding wheat varieties often have greater nutrient demand, particularly for phosphorus, to exploit their genetic yield potential. Therefore, reassessment of phosphorus fertiliser recommendations is necessary to sustain crop productivity and maintain soil fertility.

The recommended dose of fertiliser (RDF) presently followed for wheat may not always be sufficient for newly developed varieties under intensive cropping systems. Imbalanced fertilisation and inadequate phosphorus application can reduce nutrient-use efficiency and deplete soil phosphorus reserves (Havlin et al., 2014). Appropriate phosphorus management not only enhances crop yield but also helps maintain a positive phosphorus balance in soil (Ali et al., 2014; Sharma et al., 2012).

Integrated nutrient management has also been emphasised as a sustainable strategy for improving wheat yield, nutrient uptake and soil fertility by combining organic manures, inorganic fertilisers and biofertilisers (Shivani & Chugh, 2026).

Recent studies further show that phosphorus rate, conservation tillage and long-term phosphorus-fertiliser combinations can alter wheat productivity, phosphorus-use efficiency and soil physical quality in wheat-based systems (Sellami et al., 2025; Bhatia et al., 2025).

Although phosphorus plays a central role in wheat growth and nutrient uptake, information on the phosphorus requirement of the newly released wheat variety WH 1270 under the semi-arid conditions of Haryana remains limited. Existing fertiliser recommendations may not fully reflect the nutrient demand of this variety, particularly under intensive production systems where nutrient removal is high. A field-based assessment of graded phosphorus levels is therefore needed to support balanced fertiliser management for this genotype.

Keeping these facts in view, a field experiment was conducted during the rabi season of 2023–24 at the Soil Research Farm, Department of Soil Science, CCS Haryana Agricultural University, to evaluate the effect of different phosphorus levels on crop yield and nutrient content under wheat variety WH 1270. The study aimed

to determine the phosphorus requirement of the newly released wheat variety and to assess the response of wheat to varying levels and combinations of fertiliser application.

2. Methodology

The field experiment was conducted during the rabi season at the Soil Research Farm, Department of Soil Science, College of Agriculture, CCS Haryana Agricultural University. The experimental site is located in the semi-arid region of Haryana and is characterised by hot summers and cool winters. The wheat variety WH 1270 was sown at the recommended seed rate and spacing during the rabi season. Nitrogen, phosphorus and potassium fertilisers were applied through suitable fertiliser sources. Full doses of phosphorus and potassium and half of the nitrogen were applied as a basal dose at sowing, while the remaining nitrogen was top-dressed in two equal splits at critical growth stages. All agronomic practices, including irrigation, weed control and plant protection measures, were carried out uniformly for all treatments as per the recommended package of practices.

Eleven treatments comprising different levels and combinations of NPK fertilisers were evaluated: T1–Control, T2–100% RDF, T3–125% RDF, T4–150% RDF, T5–175% RDF, T6–125% P + NK, T7–150% P + NK, T8–175% P + NK, T9–125% NP + K, T10–150% NP + K and T11–175% NP + K.

At maturity, grain and straw yields were recorded from each plot and expressed in $q\ ha^{-1}$. Representative grain and straw samples were collected, oven-dried, ground and analysed for phosphorus and potassium contents using standard laboratory procedures. Phosphorus content in grain and straw samples was determined after digestion of plant material using a di-acid mixture ($HNO_3:HClO_4$). About 0.5 g of the finely ground sample was digested until a clear solution was obtained. The digest was filtered and diluted to a known volume with distilled water. Phosphorus concentration in the digest was estimated colourimetrically by the vanadomolybdophosphoric yellow-colour method using a spectrophotometer at 420 nm. The results were expressed as percentage phosphorus (% P) in grain and straw. Potassium content was determined from the same plant digest used for phosphorus estimation. The potassium concentration in the digest was measured using a flame photometer. Potassium content was expressed as percentage potassium (% K) in grain and straw. Treatment means were compared using the critical difference (CD) test at the 5% level of significance to determine the significance of treatment effects.

3. Results and Discussion

The lowest grain yield ($34.23\ q\ ha^{-1}$) and straw yield ($49.81\ q\ ha^{-1}$) were recorded under the control treatment (T1), indicating poor crop performance under nutrient-deficient conditions. Application of 100% RDF (T2) significantly enhanced grain and straw yields to 41.74 and $56.77\ q\ ha^{-1}$, respectively, demonstrating the positive response of wheat to balanced fertilisation. Further increases in phosphorus levels from 125% RDF to 175% RDF resulted in a consistent rise in crop yield. Among all treatments, T5 (175% RDF) recorded the highest grain yield ($51.93\ q\ ha^{-1}$) and straw yield ($75.80\ q\ ha^{-1}$), which was statistically superior to the control and 100% RDF treatments. The increase in yield under higher phosphorus levels may be attributed to improved root development, enhanced nutrient uptake, greater photosynthetic activity and better translocation of assimilates towards grain formation. Similar findings were reported by Ali et al. (2014), who observed a significant increase in wheat grain and straw yield with higher phosphorus application under irrigated conditions. Sharma et al. (2012) also reported that graded phosphorus levels significantly improved wheat productivity and nutrient uptake. Sharma et al. (2012) further stated that balanced phosphorus fertilisation enhanced biomass production and overall crop performance in wheat.

Treatments receiving higher phosphorus with NK fertilisers (T6–T8) also showed an improvement in yield compared with the control; however, their performance remained comparatively lower than that of the corresponding RDF treatments. Similarly, treatments with higher NP levels plus K (T9–T11) produced appreciably higher yields, with T11 (175% NP + K) recording grain and straw yields of 49.68 and $71.60\ q\ ha^{-1}$, respectively.

The critical difference (CD) values at $p = 0.05$ for grain yield ($3.06\ q\ ha^{-1}$) and straw yield ($5.00\ q\ ha^{-1}$) indicate that the observed differences among treatments were statistically significant. Overall, the study suggests that higher phosphorus application, particularly at 175% RDF, markedly enhanced wheat productivity. Table 1 shows the significant influence of different phosphorus application levels on the grain and straw yields of wheat.

The results revealed that increasing phosphorus levels progressively improved both grain and straw production over the control treatment.

Table 1. Effect of different phosphorus levels on grain and straw yields of wheat crop

Treatments	Grain yield (q ha ⁻¹)	Straw yield (q ha ⁻¹)
T ₁ : Control	34.23	49.81
T ₂ : 100% RDF	41.74	56.77
T ₃ :125% RDF	49.12	68.39
T ₄ :150 %RDF	50.96	71.59
T ₅ :175%RDF	51.93	75.80
T ₆ : 125 % P +NK	45.47	63.69
T ₇ : 150 % P + NK	46.86	63.85
T ₈ : 175 % P + NK	47.18	64.09
T ₉ : 125 % NP + K	47.98	67.83
T ₁₀ : 150 % NP + K	48.16	68.11
T ₁₁ : 175 % NP + K	49.68	71.60
CD (p=0.05)	3.06	5.00

Table 2 shows the significant effect of different phosphorus levels on phosphorus and potassium contents in wheat grain and straw. The control treatment (T₁) recorded the lowest phosphorus content in grain (0.28%) and straw (0.09%), while application of 100% RDF (T₂) increased these values to 0.36% and 0.13%, respectively. A progressive increase in phosphorus levels from 125% to 175% RDF further enhanced phosphorus concentration, with the highest values observed under T₅ (175% RDF), which recorded 0.51% phosphorus in grain and 0.22% in straw.

Similarly, potassium content also increased with higher phosphorus application. The control treatment recorded the minimum potassium content of 0.27% in grain and 0.60% in straw, whereas T₅ recorded the maximum values of 0.47% in grain and 1.36% in straw. The improvement in phosphorus and potassium contents may be attributed to greater nutrient availability, enhanced root growth, better nutrient uptake and synergistic interactions among nutrients.

Table 2. Effect of different phosphorus levels on phosphorus and potassium content in grain and straw of wheat crop

Treatments	Phosphorus (%)		Potassium (%)	
	Grain	Straw	Grain	Straw
T ₁ : Control	0.28	0.09	0.27	0.60
T ₂ : 100% RDF	0.36	0.13	0.31	0.79
T ₃ :125% RDF	0.49	0.20	0.42	1.10
T ₄ :150 %RDF	0.50	0.21	0.45	1.19
T ₅ :175%RDF	0.51	0.22	0.47	1.36
T ₆ : 125 % P +NK	0.41	0.15	0.35	0.91
T ₇ : 150 % P + NK	0.43	0.17	0.36	0.91
T ₈ : 175 % P + NK	0.44	0.18	0.37	0.93
T ₉ : 125 % NP + K	0.42	0.16	0.38	0.95
T ₁₀ : 150 % NP + K	0.44	0.18	0.4	0.98
T ₁₁ : 175 % NP + K	0.45	0.19	0.41	1.06
CD (p=0.05)	0.03	0.02	0.04	0.05

Treatments receiving higher phosphorus levels with NK (T₆–T₈) and NP + K (T₉–T₁₁) also showed appreciable improvement in nutrient content over the control, with T₁₁ recording comparatively higher values among these treatments. The CD values at p = 0.05 indicated that the differences among treatments were statistically significant. Overall, higher phosphorus fertilisation, particularly 175% RDF, significantly improved phosphorus and potassium concentrations in wheat grain and straw. Similar findings were reported by Rawal et al. (2023) and Singh (2019).

4. Conclusions

The present investigation demonstrated that graded phosphorus application significantly influenced the productivity and nutrient composition of wheat variety WH 1270. The control treatment recorded the lowest grain and straw yields, confirming the adverse effect of nutrient deficiency on crop performance. Application of 100% RDF improved yield over the control, while further increases in phosphorus levels produced a progressive improvement in grain yield, straw yield, and phosphorus and potassium contents in both grain and straw. Among the treatments, 175% RDF recorded the highest grain yield (51.93 q ha⁻¹), straw yield (75.80 q ha⁻¹), grain phosphorus content (0.51%), straw phosphorus content (0.22%), grain potassium content (0.47%) and straw potassium content (1.36%). Treatments involving higher phosphorus levels with NK or NP + K also improved crop response compared with the control, but their performance was generally lower than that of the corresponding RDF treatments. These findings suggest that balanced fertilisation, particularly with increased phosphorus in combination with nitrogen and potassium, supported better nutrient accumulation and crop productivity. Under the conditions of this single-season field experiment, wheat variety WH 1270 appeared to have a higher phosphorus requirement than the currently recommended dose, and this evidence may help refine phosphorus management for intensive wheat systems.

5. Limitations

This study was conducted during a single rabi season at one experimental site, and the findings therefore represent the response of wheat variety WH 1270 under the specific soil, climatic and management conditions of the Soil Research Farm, CCS Haryana Agricultural University. Seasonal variation, differences in soil phosphorus status, irrigation regime and long-term nutrient balance were not evaluated. The experiment focused on grain and straw yield and phosphorus and potassium contents in plant parts; it did not include detailed measurements of soil biological properties, phosphorus-use efficiency indices, residual nutrient fractions or economic returns. The treatments also assessed graded fertiliser levels under field conditions without comparing organic nutrient sources or biofertiliser combinations. Consequently, the results should be interpreted as location- and season-specific evidence. Multi-season and multi-location trials, supported by post-harvest soil testing and economic analysis, are required before broader fertiliser recommendations for WH 1270 are finalised locally for this production system.

Declaration of AI Use

This manuscript was prepared through the combined contributions of all author(s), including contributions to the study design, data, content development, results, interpretation, and related scholarly work. The author(s) acknowledge the use of Grammarly and ChatGPT to assist with grammar checking, language refinement, reference formatting. These AI-assisted tools were not used as authors and did not replace the intellectual contributions or scholarly judgment of the author(s). All AI-assisted outputs, including content, references, and interpretations, were carefully reviewed, revised, verified, and approved by the author(s). The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing Interests

Authors have declared that no competing interests exist.

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