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Effect of phosphorus application on its uptake and yield of wheat crop (*Triticum aestivum* L.)

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Abstract

A field experiment was conducted during *Rabi* 2025-26 at the Agriculture Research and Development Centre, Sakatpura, Vikrant University, Gwalior, Madhya Pradesh, to study the effect of phosphorus application through mono ammonium phosphate (MAP) on phosphorus uptake and yield of wheat (*Triticum aestivum* L.) variety JW 3288. The experiment was laid out in Randomized Block Design with six treatments and three replications. Treatments consisted of different combinations of recommended dose of nitrogen, foliar MAP, nano urea and plain water sprays at tillering and jointing stages. The treatment T₃ (75% RDN + one spray of nano urea at tillering and jointing stage + one spray of MAP at tillering and jointing stage) recorded the highest spike length (11.8 cm), grains spike⁻¹ (52.6), test weight (43.5 g), grain yield (52.10 q ha⁻¹), straw yield (73.80 q ha⁻¹) and biological yield (125.90 q ha⁻¹). Apparent total phosphorus uptake/removal, calculated from grain and straw yield, was also highest under T₃ (20.8 kg P ha⁻¹), followed by T₅ (19.8 kg P ha⁻¹). The results suggested that phosphorus supplied through MAP at critical stages improved root activity, nutrient use and yield formation, particularly when combined with foliar nano urea.

Keywords: Wheat, phosphorus, mono ammonium phosphate (MAP), grain, yield, nutrient, management

Introduction

Phosphorus is an essential macronutrient for wheat (*Triticum aestivum* L.) and plays a major role in early root development, energy transfer, tiller initiation, flowering and grain formation. Inadequate phosphorus availability restricts root growth, delays crop maturity and reduces the number of productive tillers and grain yield. Therefore, an efficient phosphorus management strategy is required for sustaining wheat productivity, particularly under intensive cereal production systems (Kumar *et al.* 2015; Jamal *et al.* 2023; Ahmadi *et al.* 2024) [5, 4, 1].

Mono ammonium phosphate (MAP) is a highly soluble phosphorus source and supplies both ammonium nitrogen and phosphate ions to the plant system. Foliar or readily available phosphorus nutrition at critical crop stages may improve metabolic activity, root growth, tiller survival and assimilate movement towards developing spikes. Previous studies reported that phosphorus application through suitable sources and levels improved wheat growth, yield attributes and yield (Kumar *et al.* 2015; Meena *et al.* 2017; Patel *et al.* 2018; Choudhary *et al.* 2020; Verma *et al.* 2021; Liu *et al.* 2023) [5, 7, 8, 2, 10, 6].

The combined use of MAP and nano urea may support balanced nutrient supply at critical crop stages. Nano urea has been reported to improve nutrient-use efficiency and productivity of wheat under irrigated conditions, while recent phosphorus studies have shown that improved phosphorus placement and availability enhance root proliferation, phosphorus accumulation, yield components and grain quality (Rawate *et al.* 2022; Liu *et al.* 2023; Ahmadi *et al.* 2024) [1, 6].

The actual benefit of phosphorus nutrition is reflected not only in yield but also in nutrient uptake or nutrient removal by the crop. Higher dry matter production and better grain yield usually increase phosphorus uptake from the soil-plant system. Keeping this in view, the present paper was prepared to evaluate the effect of phosphorus application through MAP on apparent phosphorus uptake and yield of wheat under the agro-climatic conditions of Gwalior, Madhya Pradesh.

Materials and Methods

The field experiment was conducted at the Agriculture Research and Development Centre, Sakatpura, Vikrant University, Gwalior, Madhya Pradesh during Rabi 2025-26. The experimental soil was sandy loam in texture, slightly alkaline in reaction and medium in available nitrogen and phosphorus. The wheat variety JW 3288 was grown in 3 m × 3 m plots with 22.5

cm row spacing and 10 cm plant spacing.

The experiment was laid out in Randomized Block Design with six treatments and three replications. Foliar application of MAP and nano urea was done according to the treatment schedule. Standard agronomic practices, including land preparation, irrigation, weed control and plant protection, were followed uniformly in all plots.

Table 1: Treatment details used in the experiment.

Treatment	Treatment details
T ₁	100% RDN + 1 spray of nano urea at tillering stage
T ₂	100% RDN + 1 spray of mono ammonium phosphate at tillering stage
T ₃	75% RDN + 1 spray of nano urea at tillering and jointing stage + 1 spray of mono ammonium phosphate at tillering and jointing stage
T ₄	100% RDN + plain water spray at tillering and jointing stage
T ₅	75% RDN + 1 spray of nano urea + 1 spray of mono ammonium phosphate + plain water at tillering stage
T ₆	Control + 50% RDN + plain water spray at tillering and jointing stage

Growth observations, yield attributes and yield parameters were recorded using standard procedures. Grain and straw yields were converted into q ha⁻¹. Apparent phosphorus uptake/removal was estimated for comparative interpretation by multiplying grain yield and straw yield with standard phosphorus removal coefficients of 3.0 kg P t⁻¹ grain and 0.7 kg P t⁻¹ straw, respectively. The data were analysed statistically as per Randomized Block Design, and treatment means were compared at 5 per cent level of significance wherever the F-test was significant (Gomez and Gomez 1984) [3].

Results and Discussion

Effect on growth and yield attributes

Phosphorus application through MAP, particularly when applied at tillering and jointing stages along with nano urea, improved growth and yield attributes of wheat. At harvest, T₃ recorded the highest plant height (93.6 cm), dry matter accumulation (26.5 g plant⁻¹) and effective tillers m⁻¹ row length (108.7). The improvement may be due to better root proliferation, energy transfer and nutrient absorption under adequate phosphorus supply. Better vegetative growth ultimately supported spike development and grain formation.

Table 2: Effect of phosphorus application on growth and yield attributes of wheat.

Treatment	Dry matter at harvest (g plant ⁻¹)	Effective tillers m ⁻¹ row length	Spike length (cm)	Grains spike ⁻¹	Test weight (g)
T ₁	24.3	99.5	10.8	49.3	41.6
T ₂	23.9	98.2	11.0	49.8	42.1
T ₃	26.5	108.7	11.8	52.6	43.5
T ₄	22.2	92.8	10.4	46.5	40.3
T ₅	25.4	104.3	11.5	50.8	42.7
T ₆	17.8	76.4	9.1	39.8	36.8
S.Em.±	0.66	4.36	0.45	1.72	0.95
CD (P=0.05)	1.98	12.96	1.34	5.12	2.82
CV (%)	8.60	8.30	8.70	8.30	8.00

S.Em.± = standard error of mean; CD = critical difference at 5 per cent level.

The single MAP spray treatment T₂ also improved spike length and test weight compared with T₄ and T₆, indicating the positive role of phosphorus nutrition in reproductive growth. However, the highest values were recorded under T₃, showing that phosphorus application was more effective when it was supported by balanced nitrogen nutrition. The present results are in close agreement with Kumar *et al.* (2015) [5], Patel *et al.* (2018) [8], Yadav *et al.* (2019) [11], Choudhary *et al.* (2020) [2], Liu *et al.* (2023) [6] and Ahmadi *et al.* (2024) [1], who reported improved wheat growth and yield attributes due to phosphorus fertilization and improved phosphorus availability.

Effect on yield and apparent phosphorus uptake

Yield of wheat was significantly affected by different nutrient management treatments. The maximum grain yield (52.10 q ha⁻¹), straw yield (73.80 q ha⁻¹) and biological yield (125.90 q ha⁻¹) were recorded under T₃. This treatment was followed by T₅ with grain yield of 49.35 q ha⁻¹ and straw yield of 71.10 q ha⁻¹. The lowest grain yield (34.20 q ha⁻¹) was recorded under T₆. Higher yield under T₃ may be attributed to increased effective tillers, better spike development, higher grains spike⁻¹ and greater test weight under improved phosphorus availability and balanced nutrient supply.

Table 3: Effect of phosphorus application on yield and estimated phosphorus uptake/removal of wheat.

Treatment	Grain yield (q ha ⁻¹)	Straw yield (q ha ⁻¹)	Grain P uptake (kg ha ⁻¹)	Straw P uptake (kg ha ⁻¹)	Total P uptake (kg ha ⁻¹)
T ₁	46.50	67.20	14.0	4.7	18.7
T ₂	45.95	66.75	13.8	4.7	18.5
T ₃	52.10	73.80	15.6	5.2	20.8
T ₄	42.80	63.40	12.8	4.4	17.3
T ₅	49.35	71.10	14.8	5.0	19.8
T ₆	34.20	51.00	10.3	3.6	13.8
S.Em.±	1.44	2.10	-	-	-
CD (P=0.05)	4.28	6.25	-	-	-
CV (%)	8.40	8.10	-	-	-

Apparent P uptake/removal was estimated using coefficients of 3.0 kg P t⁻¹ grain and 0.7 kg P t⁻¹ straw for comparative interpretation.

The estimated total phosphorus uptake/removal was highest under T₃ (20.8 kg P ha⁻¹), followed by T₅ (19.8 kg P ha⁻¹), T₁ (18.7 kg P ha⁻¹) and T₂ (18.5 kg P ha⁻¹). The lowest estimated uptake was observed under T₆ (13.8 kg P ha⁻¹). The higher uptake under T₃ was mainly a result of greater biomass and grain production. Better phosphorus availability likely improved root activity, ATP

formation and translocation of photosynthates, which increased yield and nutrient removal. Similar beneficial effects of phosphorus fertilization on wheat productivity were reported by Meena *et al.* (2017)^[7], Patel *et al.* (2018)^[8], Yadav *et al.* (2019)^[11], Choudhary *et al.* (2020)^[2], Liu *et al.* (2023)^[6] and Jamal *et al.* (2023)^[4].

Effect on economics

Economic analysis showed that phosphorus application through MAP with balanced foliar nutrition improved profitability. The highest net return (₹1,13,442 ha⁻¹) and B:C ratio (3.28) were recorded under T₃, followed by T₅ with net return of ₹1,06,524 ha⁻¹ and B:C ratio of 3.19. Although the cost of cultivation was slightly higher in treatments receiving foliar fertilizers, the increase in grain and straw yield resulted in better economic returns. The lowest B:C ratio (2.64) was recorded under T₆.

Table 4: Effect of phosphorus application on economics of wheat.

Treatment	Cost of cultivation (₹ ha ⁻¹)	Gross return (₹ ha ⁻¹)	Net return (₹ ha ⁻¹)	B:C ratio
T ₁	50,000	1,50,136	1,00,136	3.00
T ₂	50,600	1,51,310	1,00,710	2.99
T ₃	49,800	1,63,242	1,13,442	3.28
T ₄	47,000	1,39,164	92,164	2.96
T ₅	48,700	1,55,224	1,06,524	3.19
T ₆	41,000	1,08,435	67,435	2.64

Conclusion

The study revealed that phosphorus application through mono ammonium phosphate improved growth, yield attributes, yield and apparent phosphorus uptake of wheat. The treatment T₃ (75% RDN + one spray of nano urea at tillering and jointing stage + one spray of MAP at tillering and jointing stage) recorded the highest grain yield, straw yield, biological yield, total apparent phosphorus uptake, net return and B:C ratio. The results indicate that phosphorus application at critical stages, when combined with balanced nitrogen nutrition, can improve wheat productivity and profitability under the agro-climatic conditions of Gwalior, Madhya Pradesh.

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