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Effect of foliar urea phosphate application for improving growth, yield and productivity of rice under mid-hill conditions of Himachal Pradesh

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Abstract

A field experiment entitled “Effect of foliar urea phosphate application for improving growth, yield and productivity of rice under mid-hill conditions of Himachal Pradesh” was conducted at the Research Farm of the School of Agriculture, Abhilashi University, Mandi (H.P.) during *Kharif* season 2025. Soil of the experimental field was acidic in reaction, medium in organic carbon, low in available nitrogen, medium in available phosphorus and available potassium. The experiment was laid out in randomized block design with three replications, consisting of eight treatments i.e. T₁ Control (no nutrient), T₂ 50% recommended dose of fertilizer(RDF), T₃ 75% RDF, T₄ 100% RDF, T₅ 50% RDF + twice foliar spray (Foliar Application) of 1% Urea Phosphate, T₆ 50% RDF + twice foliar spray (Foliar Application) of 2% Urea Phosphate, T₇ 75% RDF + twice foliar spray (Foliar Application) of 1% Urea Phosphate, T₈ 75% RDF + twice foliar spray (Foliar Application) of 2% Urea Phosphate. 75% RDF along with twice foliar application of urea phosphate at 2% found more beneficial to the rice crop as compared to other application rate of NPK and urea phosphate. Treatment T₈ (75% RDF + twice foliar spray of 2% Urea Phosphate) produced maximum grain and straw yield. As higher yield with maximum profit is the sole object of farmer's to grow rice crop. Hence, on the basis of the present study, the twice foliar application of urea phosphate along with 75% RDF can be recommended to get maximum grain and straw yield and higher net returns from the rice crop

Keywords: Urea phosphate, pH, nitrogen, phosphorous and potassium

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crops in the world and serves as the staple food for more than half of the global population. It plays a crucial role in global food security and nutritional supply, particularly in Asian countries where it contributes 35–75% of daily caloric intake for over 3 billion people. Globally, rice is cultivated over an area of about 165.98 million hectares with a production of 515.53 million metric tons and an average productivity of 4.64 t ha⁻¹ during 2023–24. China leads in rice production (144.62 million metric tons), followed by India and Indonesia (Anonymous, 2024) ^[1].

In Himachal Pradesh, rice is an important Kharif crop grown mainly in mid-hill and low-hill regions. However, the productivity of rice in this region remains relatively low due to constraints such as poor nutrient management, low soil fertility, and inefficient fertilizer use. Nitrogen (N) and phosphorus (P) are the most essential macronutrients required for optimal growth and development of rice. Nitrogen is a key component of chlorophyll and amino acids, promoting vegetative growth, while phosphorus plays a vital role in root development, energy transfer (ATP), and reproductive processes (Marschner, 2012) ^[5].

Among foliar fertilizers, urea phosphate has gained considerable attention due to its dual nutrient composition and high solubility. It contains approximately 17% nitrogen and 44% P₂O₅, making it an efficient source of both N and P. Its acidic nature (pH ~1.5) enhances nutrient availability, particularly phosphorus, by reducing fixation in soil and improving micronutrient solubility (Patel *et al.*, 2020) ^[8]. Foliar application of urea phosphate has been reported to improve chlorophyll content, photosynthetic rate, tiller production, and panicle initiation, ultimately leading to increased grain yield. Additionally, it is particularly beneficial under rainfed and water-limited conditions, where root nutrient uptake is restricted.

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The integration of foliar fertilization with conventional nutrient management practices aligns well with the principles of Integrated Nutrient Management (INM), which aims to enhance nutrient use efficiency while maintaining soil health and environmental sustainability (Tandon and Tiwari, 2019) ^[11]. Such approaches are especially relevant in hill agriculture systems, where soil erosion, nutrient losses, and uneven fertilizer distribution are common challenges.

Materials and Methods

A field experiment was carried out during *kharif* season of 2025 at the Research Farm, Department of Agronomy, School of Agriculture, Abhilashi University, Chail Chowk Distt. Mandi (H.P). This experiment focused on the cultivation of rice *var. PAC 807+* during the *kharif* season of 2025. Sowing of the seeds was done on May 15, 2025. The design was Randomized Block Design in which the gross plot size was 3m × 2m, totaling 6 square meters, while the net plot size, the actual experimental area was 2.5 m × 1.5m, equivalent to 3.75 square meters. The study included 8 different treatments *i.e.* T₁ Control (no nutrient), T₂ 50% recommended dose of fertilizer(RDF), T₃ 75% RDF, T₄ 100% RDF, T₅ 50% RDF + twice foliar spray (Foliar Application) of 1% Urea Phosphate, T₆ 50% RDF + twice foliar spray (Foliar Application) of 2% Urea Phosphate, T₇ 75% RDF + twice foliar spray (Foliar Application) of 1% Urea Phosphate, T₈ 75% RDF + twice foliar spray (Foliar Application) of 2% Urea Phosphate with each treatment replicated three times, resulting in a total of 24 plots. To maintain separation between replications, a gap of 1 meter was maintained. This experimental setup aimed to explore various aspects of wheat growth and performance under different conditions and treatments. Composite soil sample was collected before to the experiment start from all three replications. It was found that the soil of experimental field was acidic in nature, low in organic carbon content and available phosphorous, medium in potassium and slightly deficient or low in available nitrogen. Harvesting is done when 90% of the grain population has turned yellow and data processing in the study was carried out with the ANOVA test.

Results and Discussion

Plant Height (cm)

Plant Height was recorded at 60, 90 days after transplanting and at harvest. Effect of foliar application of urea phosphate on plant height of rice plant have been shown in table 1 and fig. 1. and the data revealed at 60, 90 days after transplanting and at harvest, the maximum plant height (76.84cm, 92.75cm and 100.48 cm, respectively) was recorded under treatment T₈ (75% RDF + twice foliar spray of 2% Urea Phosphate), which was statistically at par with treatment T₇ (75% RDF + twice foliar spray of 1% Urea Phosphate) and treatment T₆ (50% RDF + twice foliar spray of 2% Urea Phosphate). The minimum plant height of rice (45.28 cm, 56.41 cm and 60.37 cm, respectively) was recorded under treatment T₁ (Control). It is evident from the data (table 4.1.1) that the significant increase in plant height of rice with the application of urea phosphate may be attributed to the combined supply of nitrogen and phosphorus, which are essential for vegetative growth and plant development. Nitrogen promotes cell division, chlorophyll formation, and stem elongation, while phosphorus enhances root growth, energy transfer, and nutrient uptake. Similar findings have been reported by Siddaram *et al.* (2010) ^[10] and Maqsood *et al.* (2005) ^[4].

Number of tillers (m²)

Data regarding number of tillers per square meter have been

presented in table 2 and depicted graphically in fig.2 and the data revealed that number of tillers per square meter of rice crop was significantly highest with treatment T₈ (75% RDF + twice foliar spray of 2% Urea Phosphate) at all stages of crop which was statistically at par with treatment T₇ (75% RDF + twice foliar spray of 1% Urea Phosphate), treatment T₄ (100% RDF), treatment T₆ (50% RDF + twice foliar spray of 2% Urea Phosphate) and treatment T₅ (50% RDF + twice foliar spray of 1% Urea Phosphate). The minimum number of tillers (236.42, 246.18 and 240.26, respectively) was recorded under treatment T₁ (Control). The foliar application of urea phosphate significantly increased the number of tillers in rice. The increase in tiller production may be attributed to the adequate and timely supply of nitrogen and phosphorus, which are essential for cell division, meristematic activity and vegetative growth. Nitrogen promotes the development of new shoots and tillers, while phosphorus enhances root growth and nutrient absorption, creating favorable conditions for tiller initiation. Foliar application of urea phosphate ensured rapid nutrient availability during critical growth stages, leading to improved physiological activities and greater tillering. Similar results have been reported by Larijani and Hoseini (2012) ^[3] and Siddaram *et al.* (2010) ^[10].

Dry Matter Accumulation (g m⁻²)

Data on dry matter accumulation per square meter of rice plants have been presented in table 3 and depicted graphically in fig. 3. Table 3 perusing data demonstrated that foliar application of urea phosphate gave significant results on dry matter accumulation at all stages of observation and the highest dry matter accumulation of plant was recorded under the treatment T₈ at all stages of crop which was statistically at par with treatment T₇, whereas it was statistically superior over all treatments during later stage of rice plant *i.e.* 90 DAT and at harvest. The minimum dry matter accumulation was recorded under treatment T₁. The increase in dry matter production may be attributed to the readily available supply of nitrogen and phosphorus through foliar feeding, which enhanced photosynthetic activity, nutrient uptake, and overall plant metabolism. The combined effect of these nutrients promoted better vegetative growth and biomass production, resulting in higher dry matter accumulation. Enhanced nutrient use efficiency and improved assimilate production due to foliar application of urea phosphate might have further contributed to increased dry matter yield. Similar findings have been reported by Siddaram *et al.* (2010) ^[10] and Maqsood *et al.* (2005) ^[4].

Yield Attributes

On close scanning of data presented in the table 4 and fig.4 reported that the maximum number of effective tillers, spike length and number of grains per spike was recorded under the treatment T₈ (75% RDF + twice foliar spray of 2% Urea Phosphate) at all stages of crop which was statistically at par with treatment T₇ (75% RDF + twice foliar spray of 1% Urea Phosphate), treatment T₄ (100% RDF), treatment T₆ (50% RDF + twice foliar spray of 2% Urea Phosphate) and treatment T₅ (50% RDF + twice foliar spray of 1% Urea Phosphate). Whereas, the minimum number of effective tillers, spike length and number of grains per spike under treatment T₁ (Control). The improvement was due to the foliar application of urea phosphate likely improved assimilate production and their efficient translocation to the developing panicles, resulting in better grain formation and a higher number of grains per panicle. Similar findings have been reported by Haque *et al.* (2016) ^[2] and Larijani and Hoseini (2012) ^[3]. But in case of test weight the treatments did not have any significant influence on the test weight of wheat grains. Treatment

T₈ recorded the maximum test weight, while the minimum test weight was recorded under the treatment T₁ (Control). The increased availability of phosphate and nitrogen via urea phosphate during the grain-filling stage had contributed to the improvement in test weight by facilitating improved transfer of photosynthates from source to sink. Similar results have been documented by Monica *et al.* (2020) [7].

Yield

Data pertaining to yield as influenced by foliar urea phosphate application have been presented in table 5 and delineated through fig 5. Among the foliar urea phosphate application, treatment T₈ (75% RDF + twice foliar spray of 2% Urea Phosphate) recorded significantly highest grain yield, straw yield and biological yield and it was at par with the treatment T₇ (75% RDF + twice foliar spray of 1% Urea Phosphate), treatment T₄ (100% RDF), treatment T₆ (50% RDF + twice foliar spray of 2% Urea Phosphate) and treatment T₅ (50% RDF + twice foliar spray of 1% Urea Phosphate) respectively which was mainly due to higher plant height, dry matter accumulation, number of effective tillers, test weight etc. where all these growths and yield attributing characters contributed to final straw yield of the wheat crop whereas, the control treatment (T₁) in which no fertilizers will be

applied recorded lowest grain yield, straw yield and biological yield this was due to Foliar application of urea phosphate might have improved the nutritional status and nutrient-use efficiency of the crop, resulting in increased plant height, tiller production and dry matter accumulation. The enhanced vegetative growth and greater dry matter production ultimately resulted in higher total biomass and biological yield. Similar findings have been reported by Meena *et al.* (2014) [6] and Ranjitha *et al.* (2013) [9]. However, in harvest index there was no significant effect of treatments on the harvest index of the wheat crop. the maximum harvest index (42.51%) was recorded under treatment T₈ which was statistically at par with treatment T₇ and treatment T₆ while the minimum harvest index (41.00%) was recorded under treatment T₁ (Control). The increase in harvest index may be attributed to the more efficient partitioning of assimilates from vegetative parts to the grain yield. Improved grain filling and higher grain yield relative to total biological yield resulted in a greater harvest index. Furthermore, the enhanced physiological efficiency of the crop under urea phosphate application might have contributed to better conversion of biomass into grain yield. Similar findings have been reported by Meena *et al.* (2014) [6] and Ranjitha *et al.* (2013) [9].

Table 1: Effect of foliar application of urea phosphate on plant height (cm) of transplanted rice

Sr. No.	Treatment	60 DAT	90 DAT	At harvest
T ₁	Control (no nutrient)	45.28	56.41	60.37
T ₂	50% RDF	50.74	62.18	66.92
T ₃	75% RDF	54.63	68.57	73.21
T ₄	100% RDF	67.89	82.46	88.94
T ₅	50% RDF + twice foliar spray of 1% Urea Phosphate	62.46	75.24	80.18
T ₆	50% RDF + twice foliar spray of 2% Urea Phosphate	64.15	78.83	84.76
T ₇	75% RDF + twice foliar spray of 1% Urea Phosphate	71.52	86.18	94.37
T ₈	75% RDF + twice foliar spray of 2% Urea Phosphate	76.84	92.75	100.48
	SEm±	2.78	3.02	2.71
	CD at 5%	8.46	9.19	8.24

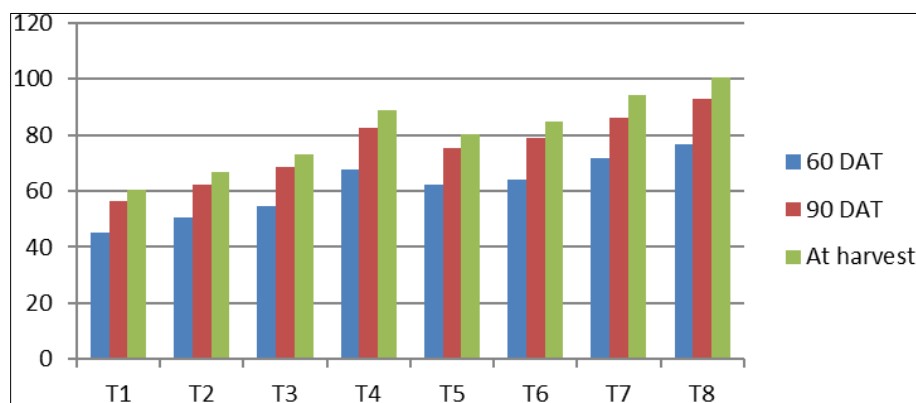


Fig 1: Effect of foliar application of urea phosphate on plant height (cm) of transplanted rice

Table 2: Effect of foliar application of urea phosphate on number of tillers (m⁻²) of transplanted rice

Sr. No.	Treatment	60 DAT	90 DAT	At harvest
T ₁	Control (no nutrient)	236.42	246.18	240.26
T ₂	50% RDF	248.57	256.84	246.71
T ₃	75% RDF	258.16	264.73	259.94
T ₄	100% RDF	291.86	299.78	296.41
T ₅	50% RDF + twice foliar spray of 1% Urea Phosphate	283.21	291.43	288.52
T ₆	50% RDF + twice foliar spray of 2% Urea Phosphate	286.74	294.62	291.18
T ₇	75% RDF + twice foliar spray of 1% Urea Phosphate	298.47	313.12	309.84
T ₈	75% RDF + twice foliar spray of 2% Urea Phosphate	311.92	323.56	319.07
	SEm±	7.95	5.92	6.14
	CD (P=0.05)	24.18	18.00	18.67

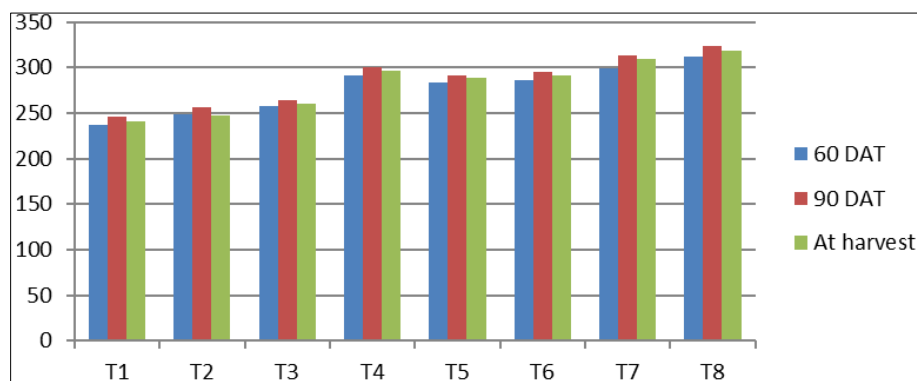


Fig 2: Effect of foliar application of urea phosphate on number of tillers (m^{-2}) of

transplanted rice

Table 3: Effect of foliar application of urea phosphate on dry matter accumulation (g m^{-2}) of transplanted rice

Sr. No.	Treatment	60 DAT	90 DAT	At harvest
T ₁	Control (no nutrient)	332.14	474.82	507.96
T ₂	50% RDF	437.28	582.76	617.14
T ₃	75% RDF	537.85	732.48	749.62
T ₄	100% RDF	674.52	782.61	802.94
T ₅	50% RDF + twice foliar spray of 1% Urea Phosphate	609.18	765.82	767.24
T ₆	50% RDF + twice foliar spray of 2% Urea Phosphate	632.76	779.24	807.85
T ₇	75% RDF + twice foliar spray of 1% Urea Phosphate	719.36	812.48	840.76
T ₈	75% RDF + twice foliar spray of 2% Urea Phosphate	772.14	937.82	964.58
	SEM $\pm$	19.54	30.86	37.37
	CD (P=0.05)	59.43	93.86	113.67

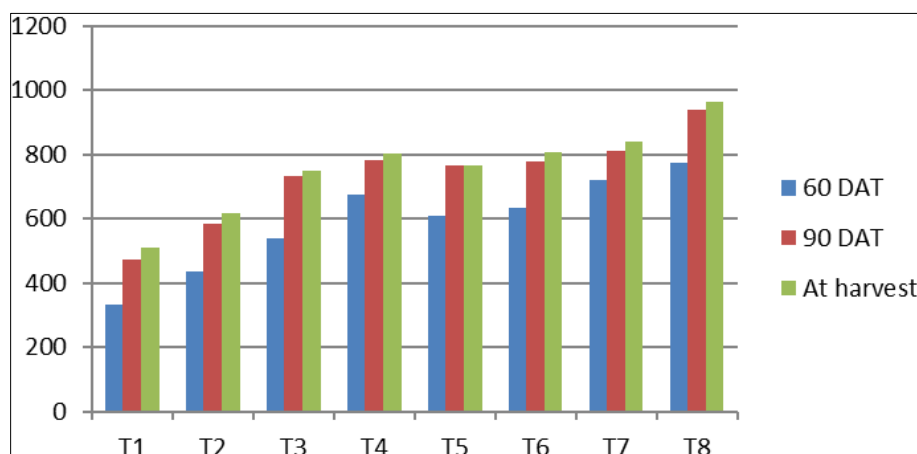


Fig 3: Effect of foliar application of urea phosphate on dry matter accumulation (g m^{-2}) of transplanted rice

Table 4: Effect of foliar application of urea phosphate on yield attributes of rice

Sr. No.	Treatment	No. of effective tillers (m^{-2})	Spike length (cm)	No. of grain per spike	Test weight (g)
T ₁	Control (no nutrient)	226	11.12	64	21.00
T ₂	50% RDF	232	13.86	68	21.67
T ₃	75% RDF	245	14.41	71	22.33
T ₄	100% RDF	277	16.27	78	23.83
T ₅	50% RDF + twice foliar spray of 1% Urea Phosphate	268	15.94	76	23.17
T ₆	50% RDF + twice foliar spray of 2% Urea Phosphate	270	16.08	77	23.67
T ₇	75% RDF + twice foliar spray of 1% Urea Phosphate	288	16.71	79	24.33
T ₈	75% RDF + twice foliar spray of 2% Urea Phosphate	297	18.52	82	25.17
	SEM $\pm$	6.67	0.62	1.98	0.70
	CD (P=0.05)	20.29	1.88	6.03	NS

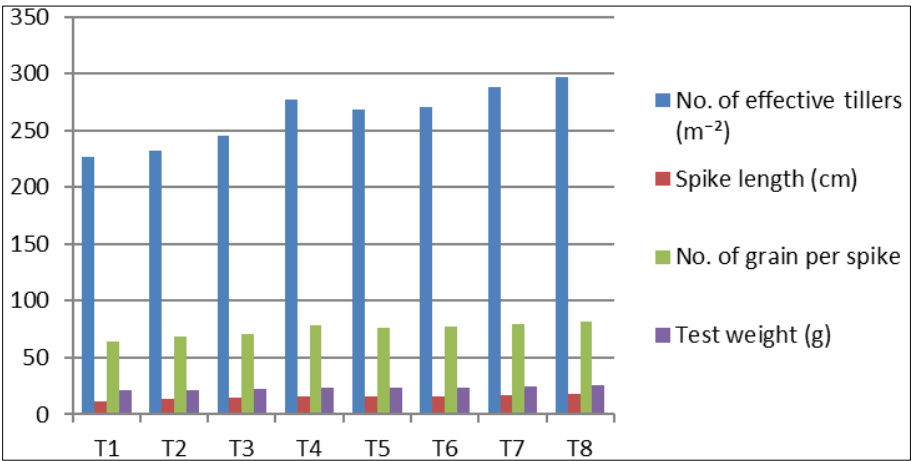


Fig 4: Effect of foliar application of urea phosphate on yield attributes of transplanted rice

Table 5: Effect of foliar application of urea phosphate on yield of transplanted rice

Sr. No	Treatment	Grain Yield (q ha ⁻¹)	Straw Yield (q ha ⁻¹)	Biological Yield (q ha ⁻¹)	Harvest Index (%)
T ₁	Control (no nutrient)	29.42	42.33	71.75	41.00
T ₂	50% RDF	33.29	46.66	79.95	41.64
T ₃	75% RDF	35.83	50.67	86.50	41.42
T ₄	100% RDF	37.81	56.00	93.81	40.30
T ₅	50% RDF + twice foliar spray of 1% Urea Phosphate	40.54	57.67	98.21	41.28
T ₆	50% RDF + twice foliar spray of 2% Urea Phosphate	42.48	58.33	100.81	42.14
T ₇	75% RDF + twice foliar spray of 1% Urea Phosphate	43.60	60.67	104.27	41.82
T ₈	75% RDF + twice foliar spray of 2% Urea Phosphate	46.48	62.86	109.34	42.51
	SEm (±)	1.79	1.51	2.34	0.72
	CD (P=0.05)	5.45	4.59	7.11	NS

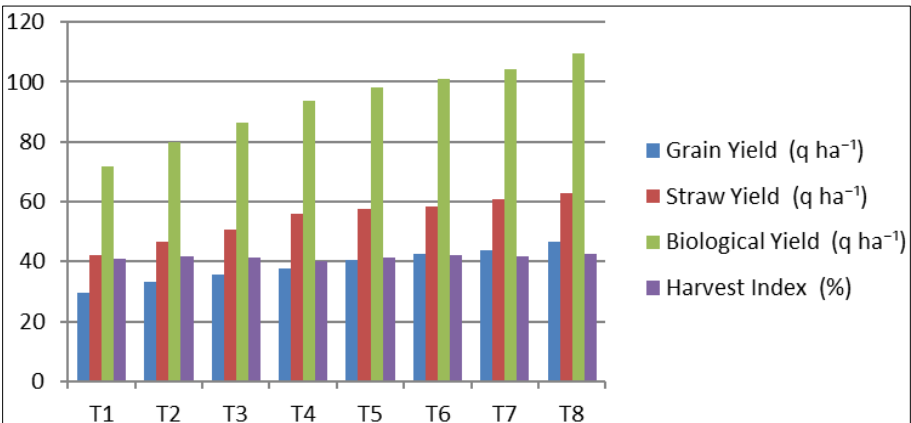


Fig 5: Effect of foliar application of urea phosphate on yield of transplanted rice

Conclusion

The findings of this study clearly demonstrate that the integrating 75% Recommended Dose of Fertilizers (RDF) with two foliar applications of 2% urea phosphate (Treatment T₈) significantly optimizes rice performance over other nutrient combinations. This specific regimen achieved the highest grain and straw yields, resulting in the most favorable benefit-cost (B:C) ratio. Given that maximizing productivity and economic profitability is central to rice cultivation, applying a 2% urea phosphate foliar spray twice alongside 75% RDF serves as an effective agronomic recommendation to enhance both crop output and net returns.

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