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Effect of Different Phosphatic Fertilizers on Productivity of Wheat (*Triticum aestivum* L.)

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Abstract
The present investigation entitled "Effect of Different Phosphatic Fertilizers on Productivity of Wheat (*Triticum aestivum* L.)" was conducted during the *Rabi* season of 2025-26 at the B2 Instructional Farm, Rajasthan College of Agriculture, Udaipur (Rajasthan). The experimental results indicated that the application of 100 per cent recommended dose of phosphorus through SSP along with Nano P as seed treatment and two foliar sprays at 30 and 45 DAS (T_{10}) produced significantly superior growth and yield of wheat over the control and most of the other treatments. The highest grain yield, straw yield, biological yield and harvest index were also obtained under T_{10}.

Keywords: Yield, nano p, SSP, wheat, seed treatment, foliar spray

1. Introduction
Wheat (*Triticum aestivum* L.) is the second important food crop after rice worldwide. It represents the prominent cereal crop and covers 17 per cent of global crop land. It is the most important stable food crop for more than one third of the world population and contributes more calories and proteins to the world diet than any other cereal crops. Total wheat cultivation area in the country was reported to be 31.83 million hectares, with a production of 113.29 million tonnes and an average productivity of 3559 kg ha^{-1}. In Rajasthan, wheat was cultivated in an area of 2.74 million hectares, contributing a production of 9.7 million tonnes with a slightly higher productivity of 3540 kg ha^{-1}, compared to the national average (E, S&E Division, DA&FW, 2024).

Phosphorus is second most yield limiting nutrient after nitrogen in agricultural production across the world. It plays many key functions in plant life especially in the storage and transfer of energy, photosynthesis, respiration, cell division and enlargement. Plants take P in $H_2PO_4^-$ or HPO_4^{-2} forms from the soil solution (Izhar Shafi *et al*., 2020) [6]. Phosphorus (P) is involved in almost all biochemical pathways as a component part of energy carrier compounds, ATP and ADP. Phosphorus is one of the 17 essential elements required for plant growth and reproduction. It is used in the plant for maintenance and transfer of genetic code and is structural component of cells and many biochemicals. Phosphorus deficiencies results in poor root growth, stunted top growth, reduced yield and crop quality along with delayed maturity. It can be easily noticed in the significant impact it has on the yield of the plant (Mishra, 2012) [9].

Application of phosphorous in adequate quantity and available source to plant medium has a vital role for plant growth and improving yield of wheat. Phosphorous is essential for cell division, seed and fruit development (Rekani *et al*., 2017) [11]. Phosphorus can significantly increase vegetative growth and grain yield. It is involved in enzymatic reactions in the plant. Phosphorus is essential for cell division because it is a constituent element of nucleoproteins which are involved in the cell reproduction processes (Azeem *et al*., 2018) [2]. A mineral macronutrient, P, is found in soil mostly in insoluble forms and is crucial for various physiological processes in plants. P absorption capacity of the soil controls the concentration of dissolved P. Due to the high capacity of the soil to absorb P, its mobility in the soil is low compared to other food elements to absorb P. Therefore, all the P fertilizer consumed is not used by the plant at the time of consumption.

The increase in agricultural productivity and decrease in pollution are both promoted by improving plant P uptake from the soil. Due to slow diffusion and high soil fixation, P is a unique nutrient with a low availability. Growing plants can be limited by P. In the past decades, chemical fertilizers have improved soil P fertility and crop production (Fathi and Mehdiniya 2023) [4].

Plants often absorb about 50 per cent of their seasonal P requirements by the time they have accumulated 25 per cent of their total seasonal dry mass. Thus, plant's early P requirements are critical. Unlike nitrogen (N), which can be top-dressed as fertilizer 2-3 times during the growing season, generally P fertilization entails a one-time basal application to the soil before or soon after plant emergence. Because organic P must be converted to inorganic P through a relatively slow mineralization process before it becomes available to plants, organic fertilizers may not meet plants' early P requirements, often resulting in lower crop yield. Furthermore, unlike conventional chemical N fertilizers which are all water soluble, P fertilizers vary widely in solubility that can influence the initial and residual P effects. For this and other reasons, inorganic P fertilizers remain the major sources of P application used by farmers in both developed and developing countries. Inappropriate or excessive use of P fertilizers has been linked to environmental pollution, including heavy metal contamination in soils, and P runoff can contribute to the eutrophication of water bodies (Chien *et al*., 2011) [3].

2. Materials and Methods

The field experiment was conducted during the *Rabi* season of 2025-26 at the B_2, Instructional Farm (Agronomy), Rajasthan College of Agriculture, Udaipur. The college is located at an elevation of 582.2 m above mean sea level and lies at 24°35′ N latitude and 73°42′ E longitude. The experiment was laid out in Randomized Block Design with 3 replications. There were 10 plots in each replication, where SSP and Nano P fertilizer used. The recommended dosage of NPK for wheat cultivation is 120:60:40 kg ha^{-1}, respectively. The first foliar spray of nano DAP fertilizer was applied at 30 DAS and second at 45 DAS. The experiment consisted of ten treatments, namely T_1: Control, T_2: 50% RDP through SSP, T_3: 75% RDP through SSP, T_4: 100% RDP through SSP, T_5: 50% RDP through SSP and Nano P (Seed treatment), T_6: 75% RDP through SSP and Nano P (Seed treatment), T_7: 100% RDP through SSP and Nano P (Seed treatment), T_8: 50% RDP through SSP and Nano P (Seed treatment) + Nano P (2 foliar spray at 30 DAS and 45 DAS), T_9: 75% RDP through SSP and Nano P (Seed treatment) + Nano P (2 foliar spray at 30 DAS and 45 DAS), and T_{10}: 100% RDP through SSP and Nano P (Seed treatment) + Nano P (2 foliar spray at 30 DAS and 45 DAS). The wheat ear heads harvested from each net plot were collected and stored in gunny bags. The harvested material was thoroughly sun-dried and then processed through threshing, winnowing, and cleaning operations. Following 3-4 days of sun drying, the grain weight from each plot was measured and subsequently converted into grain yield expressed in kilograms per hectare (kg ha^{-1}). Straw yield was determined by deducting the grain yield from the biological yield recorded for each plot. The resulting straw yield was then expressed in kilograms per hectare (kg ha^{-1}). The harvested bundles from each net plot were sun-dried and subsequently weighed to determine the biological yield. The biological yield was then expressed in kilograms per hectare (kg ha^{-1}). The harvest index (HI) was calculated as the ratio of economic yield (grain yield) to biological yield following the method proposed by Donald and Hamblin and expressed as a percentage.

Grain yield (kg ha^{-1})

HI (%) = Biological yield (kg ha^{-1}) × 100

3. Results and discussion

3.1 Yield attributes and yield

Grain yield

An analysis of the data presented in Table 1 showed that application of different amounts of phosphatic fertilizers significantly enhance the grain yield of wheat**.** The maximum grain yield (4798 kg ha^{-1}) was found with the application of 100% RDP through SSP and Nano P seed treatment + two foliar spray of Nano P at 30 DAS and 45 DAS) (T10), which was significantly superior over T_6 (50% RDP through SSP and Nano P Seed treatment), T_3 (75% RDP through SSP), T_8 (50% RDP through SSP + Nano P seed treatment + two foliar sprays of Nano P at 30 and 45 DAS), T_5 (50% RDP through SSP and Nano P Seed treatment), T_2 (50% RDP through SSP), However it was found statistically at par with treatment T_9 (75% RDP through SSP + Nano P seed treatment + two foliar sprays of Nano P at 30 and 45 DAS), T_7 (100% RDP through SSP and Nano P Seed treatment) and T_4 (100% RDP through SSP). Minimum grain yield (3244.41 kg ha^{-1}) was recorded in treatment T_1 (Control). The data further indicates that treatment T_{10} found significantly superior over T_1, T_2, T_3, T_5, T_6 and T_8 with the magnitude of 47.89, 30.01, 13.35, 18.41, 8.08, 14.85 per cent, respectively. The high potential of nano-fertilizers to provide nutrients to plants in a controlled and sustained manner throughout the crop growth period significantly improved wheat yield attributes and overall grain yield. The enhanced growth may be attributed to increased production of growth hormones and improved photosynthetic activity resulting from the application of nano-fertilizers. This sustained phosphorus availability supported better crop growth, enhanced dry matter accumulation and efficient partitioning of assimilates to the economic yield, thereby resulting in significantly higher yield and yield parameters. Nano DAP was particularly effective in promoting root development, enhancing nutrient uptake and improving photosynthetic efficiency, which collectively contributed to higher wheat productivity (Kumar and Dahiya *et al.*, 2024) [7]. The improvement in wheat productivity following the application of different phosphatic fertilizers is also supported by findings from Saqib *et al.* (2023), Maloth *et al*. (2024), Reddy *et al.* (2025) [8, 10, 12].

4. Straw yield

An investigation of data presented in Table 1 shows that the straw yield significantly enhanced by application of different phosphatic fertilizers. The maximum straw yield (6798 kg ha^{-1}) was observed with the application of 100% RDP through SSP and Nano P seed treatment + Nano P two foliar spray of Nano P at 30 DAS and 45 DAS (T_{10}), which was significantly superior over T_4 (100% RDP through SSP), T_6 (50% RDP through SSP and Nano P Seed treatment), T_3 (75% RDP through SSP), T_8 (100% RDP through SSP + Nano P seed treatment + two foliar sprays of Nano P at 30 and 45 DAS), T_5 (50% RDP through SSP and

Nano P Seed treatment), T_2 (50% RDP through SSP), However it was statistically at par with treatment T_9 (75% RDP through SSP + Nano P seed treatment + two foliar sprays of Nano P at 30 and 45 DAS) and T_7 (100% RDP through SSP and Nano P Seed treatment). Minimum straw yield was recorded in treatment T_1 (Control). The data also demonstrated that the application of treatment T_{10} improved the straw yield of wheat over T_1, T_2, T_3, T_4, T_5 and T_8 with the magnitude of 63.46, 50.22, 17.77, 8.7, 13.83, and 21.95 per cent, respectively. The combined application of soil fertilizers (N, P, K, and Zn) significantly enhanced straw yield demonstrating the superiority of integrated soil and foliar nano-fertilizer application (Gangwar *et al*., 2022) [5].

5. Biological yield

The data given in Table 1 revealed that the biological yield was significantly increased with the application of varying phosphatic fertilizers during the experimentation. The maximum biological yield (11596 kg ha^{-1}) was noted with the application of 100% RDP through SSP and Nano P seed treatment + two foliar spray of Nano P at 30 DAS and 45 DAS (T_{10}), which was significantly superior over T_4 (100% RDP through SSP), T_6 (50% RDP through SSP and Nano P Seed treatment), T_3 (75% RDP through SSP), T_8 (50% RDP through SSP + Nano P seed treatment + two foliar sprays of Nano P at 30 and 45 DAS), T_5 (50% RDP through SSP and Nano P Seed treatment) and T_2 (50% RDP through SSP). However, it was statistically at par with treatment T_9 (75% RDP through SSP + Nano P seed treatment + two foliar sprays of Nano P at 30 and 45 DAS) and T_7 (100% RDP through SSP and Nano P Seed treatment). Although, the minimum biological yield was recorded in treatment T_1 (control). The data also demonstrated that the application of T_{10} increased the biological yield of wheat by up to 56.64 per cent over the no application of phosphorus (control). According to the study conducted by Liang *et al.* (2024), different P fertilizers increased the average yield of wheat as it is a key component of ATP and nucleic acids, which are involved in energy transfer, cell division and the synthesis of carbohydrates and proteins. Adequate phosphorus nutrition enhances photosynthetic efficiency and facilitates the translocation of assimilates from source leaves to developing spikes and grains. Consequently, improved grain filling results in higher test weight, grain yield, straw yield and biological yield. The combined application of single superphosphate (SSP) with nano phosphorus through seed treatment and foliar sprays likely ensured a continuous supply of available phosphorus during both vegetative and reproductive stages, minimizing nutrient losses and improving phosphorus use efficiency (Thakur *et al.* 2024) [13].

6. Harvest index

The data illustrated in Table 1 showed that the application of different phosphatic fertilizers were found non-significant in case of harvest index of wheat. However, the values of the harvest index ranged between 41.38 to 44.85 per cent.

Table 1: Effect of different phosphatic fertilizers on yield attributes and yield

Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
T_1 - Control	3244	4158	7403	43.81
T_2 - 50% RDP through SSP	3690	4525	8215	44.85
T_3 - 75% RDP through SSP	4233	5772	10005	42.32
T_4 - 100% RDP through SSP	4534	6251	10785	42.05
T_5 - 50% RDP through SSP and Nano P (Seed treatment)	3971	5270	9242	42.97
T_6 -75% RDP through SSP and Nano P (Seed treatment)	4439	5972	10411	42.66
T_7 -100% RDP through SSP and Nano P (Seed treatment)	4615	6478	11094	41.60
T_8 -50% RDP through SSP and Nano P (seed treatment) + Nano P (2 foliar spray at 30 DAS and 45 DAS)	4177	5574	9752	42.84
T_9 -75% RDP through SSP and Nano P (seed treatment) + Nano P (2 foliar spray at 30 DAS and 45 DAS)	4703	6639	11342	41.48
T_{10} -100% RDP through SSP and Nano P (seed treatment) + Nano P (2 foliar spray at 30 DAS and 45 DAS)	4798	6798	11596	41.38
SEm (±)	96.96	133.08	187.96	0.68
CD (p=0.05)	288.08	395.39	558.46	2.03

Conclusion

On the basis of results of experiment conducted during the *Rabi* 2025-26, it was concluded that the yield attributes and yield *viz.*, grain yield, straw yield and biological yield after harvest of wheat was reported with the application of treatment T_{10} (100% RDP through SSP and Nano P (seed treatment) + Nano P (2 foliar spray at 30 DAS and 45 DAS).

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