Effect of Different Methods of Phosphorus Application on Growth and Agronomic Traits of Wheat Under Arid and Semi-Arid Conditions of Bannu Division

Abdul Quddoos[1], Khalid Mahmood[1], Muhammad Ali[1], Muhammad Farooq[1], Waqar Ahmad[2] and Alamgir Khan[3]

[1]Agricultural Research Station Serai Naurang Khyber Pakhtunkhwa Pakistan.

[2]Agricultural Research Station Bannu, Khyber Pakhtunkhwa Pakistan.

[3]Shaheed Benazir Bhutto University, Sheringal, Upper Dir Khyber Pakhtunkhwa Pakistan.

***Correspondence**: abashaheed47@gmail.com

Citation | Quddoos. A, Mahmood. K, Ali. M, Farooq. M, Ahmad. W, Khan. A, "Effect of Different Methods of Phosphorus Application on Growth and Agronomic Traits of Wheat Under Arid and Semi- Arid Conditions of Bannu Division", IJASD, Vol. 7 Issue. 4 pp 550-556, October 2025

Received| September 25, 2025 **Revised|** October 15, 2025 **Accepted|** October 20, 2025 **Published|** October 25, 2025.

The effect of different methods of Phosphorus application was tested on wheat for two seasons, Rabi 2022-23 and 2023-24 at Agricultural Research Station Serai Naurang (Bannu) Khyber Pakhtunkhwa Pakistan. Five methods of application such as application by broadcast method (MP1), application through mixing with seed at the time of sowing (MP2), placing by drill below the seed at the time of sowing (MP3), placing by drill on one side of the row of crop (MP4) and placing by drill with both sides of the row of the crop (MP5) were tested. Variety Khaista-2017 was used during this investigation. The study was focused on growth traits and yield parameters. The highest significant grain yield (6864 kg ha^{-1}), biological yield (17990 kg ha^{-1}), 1000 grain weight (50 grams), grain per spike (66), tillers m^{-2} (441), spike m^{-2} (449), plant height (100.15 cm) and harvest index (38.58 %) were noted when Phosphorus was placed by drill on both sides of the crop row. The 2nd most encouraging results were recorded for the method of placing by drill on one side of crop row. This research will help to solve food security problem. Findings of this research will also assist farming community to use suitable method of Phosphorus application and update their production technology. Moreover, by applying results of this research, plant breeders will evolve and develop genotypes of wheat with great potential.

Keywords: Application Methods; Phosphoric Fertilizer; Wheat Yield.

Introduction:

Pakistan is a country where approximately 70–75% of the population is directly or indirectly connected to agriculture. The nation's major industries rely heavily on agricultural raw materials, making its economy predominantly agrarian. Agriculture has long been a major contributor to Pakistan's economic development, accounting for 30–40% of national savings and serving as the primary source of employment and livelihood for the majority of the population[1][2]. However, its share in GDP has declined to 19.3% over the past few decades. Despite this decline, significant potential exists to boost agricultural output and increase its GDP contribution by adopting modern and advanced agricultural technologies[3]. Pakistan, similar to many developing nations, struggles with low agricultural yields per acre. Moreover, unlike some countries, it cannot significantly increase its cultivated land to boost production. Therefore, the challenge of low yield per acre can only be addressed by increasing the production of food grains. Agriculture remains the primary

source of these essential crops. Therefore, it is felt with great need that production of food grains should be increased, which will not only solve the problem of food security but also help to increase the country's foreign exchange reserves and achieve self-sufficiency in food items.

Wheat (Triticum aestivum L.) is a staple food crop, providing food grains to a large portion of the global population and serving as a key source of essential nutrients[4]. According to[5], wheat, being a major source of calories, protein, dietary fiber, vitamins, and various essential minerals, has a higher nutritive value than any other cereal crop. The increase in population rate and change in dietary habit has resulted in an increase of cereal demand for many years[6][7]. In the presence of challenges such as dangers of climate change, limited opportunities to increase cropland, and a sharp rise in freshwater scarcity, cropping systems will have to increase production to meet the demand [8][9][10]. Various agronomic practices are applied to enhance crop yield. Among these, the type of fertilizer, its dosage, and timing and method of application are particularly important in influencing the growth and productivity of wheat. Mainly Nitrogen, Phosphorus and Potassium manures are used. Phosphorus is one of the most essential nutrients for plants, required in large amount second to nitrogen[11]. As a key macronutrient, phosphorus plays a vital role in wheat production. It accelerates plant maturity, limits excessive vegetative growth, and enhances grain quality. Moreover, it plays a vital role in many other biochemical functions like cell division, function of many enzymes and protein synthesis. It is very essential for various metabolic processes such as plant growth, root development, tillering, flowering, grain yield, and biomass accumulation in cereals[12]. Phosphorus fertilizers are very costly nowadays and its efficiency is very low in Pakistani soil so maximum and high use efficiency of the Phosphorus fertilizers is the target of the farmers to get maximum economic return. In Pakistan Phosphorus fertilizers are commonly applied to the soil surface through broadcasting and incorporated during sowing[13]. However, a large portion of the phosphorus becomes insoluble with this method, resulting in variable availability of phosphorus to plants in the soil[14]. The nature of reaction of Phosphorus is different depending upon the chemistry of soil and pH range. In acidic soil Iron and Aluminium are present so it forms complex compounds of these elements while in calcareous soil (prevailing in Pakistan) it forms dicalcium phosphate, tri- calcium phosphate and octa-calcium phosphate. In all these cases, solubility of Phosphorus is much lower than that of the water-soluble Phosphorus. The efficiency of applied fertilizers may be improved only through placement method and synchronized application at growth stage [15]. Band placement of Phosphorus has been recommended to increase Phosphorus use efficiency[16]. It has been also reported by[17] that Phosphorus use efficiency and wheat yield increased by placement method of Phosphorus application than broadcast method of application.

In light of these considerations, a field experiment was conducted to evaluate the effect of different phosphorus application methods on the growth and yield of wheat under the agro-ecological conditions of the Bannu Division, Khyber Pakhtunkhwa, Pakistan.

Materials and Methods:

The experimental trial for two years Rabi seasons 2022-23 and 2023-24 was conducted consecutively at research station of agriculture located in Serai Naurang, Bannu, Khyber Pakhtunkhwa, Pakistan to find out the best and efficient method of Phosphorus application. The application of Phosphorus was done through following methods, application by broadcast method (MP1), application through mixing with seed at the time of sowing (MP2), placing by drill below the seed at the time of sowing (MP3), placing by drill on one side of the row of crop (MP4) and placing by drill with both sides of the row of the crop (MP5). The trials were conducted using the wheat variety Khaista-2017. A randomized complete block design was implemented, with each plot covering 9 m^2 (1.8 m × 5 m) and

replicated three times. Nitrogen and phosphorus fertilizers were applied at rates of 120 kg/ha and 90 kg/ha, respectively. Phosphorus fertilizer was applied at the time of sowing, while the nitrogenous fertilizer was split into two or three equal doses and applied at appropriate intervals. The herbicide Axial was applied at 330 ml per acre was used to control narrow-leaved weeds, while Allymax @14 gram/ Acre was applied for broad-leaved weeds. Both were applied during December and January. This experiment continued for two years, and the average values of the two years' data were recorded for different traits. Data was recorded for traits such as plant height (cm), grains spike^{-1}, spike length (cm), spike m^{-2} , 1000 grains weight (gram), tillers m^{-2} , grain yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index percentage and analyzed statistically through Excel ANOVA

Results:

Plant Height (cm):

Table.1 showed that the maximum plant height was recorded in MP2 and MP5 (100.15 cm each), followed by MP4 (100.00 cm) and MP1 (99.50 cm), while the lowest average height was observed in MP3 (99.15 cm), followed by MP1 (99.50 cm).

Length of Spike (cm):

Table.1 indicated that MP5 produced the longest average spike length (11.96 cm), followed by MP4 and MP2 (11.73 cm each), while MP3 recorded the shortest average spike length (11.66 cm), followed by MP1 (11.67 cm).

Spike m^{-2}:

Table.1 revealed that the highest average number of spikes per m² (449) was recorded for MP5, followed by MP4 (436 spikes), while the lowest averages were observed in MP1 (410 spikes) and MP3 (412 spikes).

Grains per Spike:

Table.2 showed that MP5 produced the highest number of grains per spike (66), whereas MP1 recorded the lowest average number of grains per spike (58).

1000 Grains Weight (grams):

Table.2 showed that the maximum 1000-grain weight was recorded for MP5 (50.00 g), while the lowest was observed in MP1 (46.35 g).

Tillers m^{-2}:

Table.2 indicated that MP5 produced maximum average tillers m^{-2} (441) followed by MP4 (422 tillers) while the MP1 got the lowest tillers (399)

Biological yield (Kg/ha):

Table.3 revealed that the highest biological yield ha^{-1} (17990 kg) was recorded for MP5 and 2nd highest biological yield was got by MP3 (17531 kg) while the lowest average biological yield was got by MP2 (15864 kg) followed by MP4 (16882 kg).

Yield/hectare (Kg):

Table.3 indicated that MP5 got the highest significant average grain yield ha^{-1} (6864 kg) followed by MP4 (6279 kg) while MP1 produced the lowest grain yield (5816 kg).

Harvest Index %:

Table.3 showed that MP5 obtained the highest average harvest index (38.58 %) and MP2 got the next highest harvest index (38.13 %) while the lowest harvest index was noted for MP1 (34.10 %)

Table 1. Effect of different application methods of Phosphorus on the characteristics of wheat.

Treatment	Plant Height (cm)			Spike Length (cm)			Spike m-2		
	2022-23	2023-24	Average	2022-23	2023-24	Average	2022-23	2023-24	Average
MP1	101	98.00	99.50^{cab}	11.70	11.65	11.67^{dabc}	419	400	410^{ebcd}
MP2	100	100.30	100.15^{a}	11.74	11.70	11.72^{cab}	460	390	425^{cab}
MP3	101	97.30	99.15^{dabc}	11.60	11.73	11.66^{eabcd}	426	398	412^{dbc}
MP4	102	98.00	100.00^{ba}	11.60	11.87	11.73^{ba}	464	408	436^{ba}
MP5	103	97.30	100.15^{a}	12.00	11.93	11.96^{a}	470	428	449a
LSD 0.05			7.06			0.84			30.34

Table. 2. Effect of different application methods of Phosphorus on agronomic traits of wheat.

Treatment	Grains Spike^{-1}			1000 grains weight (grams)			Tillers/m^2		
	2022-23	2023-24	Average	2022-23	2023-24	Average	2022-23	2023-24	Average
MP1	57	58	58^{dc}	48	44.70	46.35^{ecd}	418	380	399^{ebcd}
MP2	58	62	60^{cb}	50	42.85	46.42 ^{dc}	449	381	415^{cab}
MP3	60	60	60^{cb}	50	44.83	47.41^{cb}	412	392	402^{dbc}
MP4	62	65	64^{ba}	50	48.40	49.20^{ba}	448	395	422^{ba}
MP5	64	67	66^{a}	52	47.36	50.00^{a}	462	420	441^{a}
LSD 0.05			4.45			2.17			29.70

Table. 3. Effect of different application methods of Phosphorus on the yield parameters of wheat.

Treatment	Biological Yield (Kg ha^{-1})			Grain Yield (Kg ha^{-1})			Harvest Index (%)		
	2022-23	2023-24	Average	2022-23	2023-24	Average	2022-23	2023-24	Average
MP1	17675	16431	17053^{cb}	5891	5741	5816^{ecd}	33.32	34.94	34.10^{ed}
MP2	16667	15061	15864^{e}	5805	6295	6050^{cb}	34.82	41.79	38.13^{ba}
MP3	18182	16880	17531^{ba}	6089	5872	5981^{dbc}	33.49	34.78	34.12^{d}
MP4	18250	15513	16882^{dbc}	6452	6105	6279^{b}	35.35	39.35	37.19^{cab}
MP5	18687	17293	17990^{a}	6927	6801	6864^{a}	37.60	39.32	38.58^{a}
LSD 0.05			789.92			446.77			2.56

Discussion:

In table No.1 statistical analysis for plant height indicated that MP2 and MP5 were comparable to all other treatments and showed no significant difference between each other. Similar results were reported by [16][18], and these findings are also consistent with those of [19]. Similarly, statistical analysis for length of spike showed that MP5 was comparable to all other treatments which aligns with the findings of[16][18] and is also consistent with the results reported by[19]. As for as the spikes m^{-2} is concerned the statistical analysis showed that MP5 had significant spikes m^{-2} as compared to MP1 and MP3 but at par with MP2 and MP4. These findings are consistent with[16][18] and align with the results reported by[19].

Table No. 2 showed that statistically MP5 got the significant result as compared to MP1, MP2, and MP3 for grain $spike^{-1}$ but at par result with MP4. Results of this research work are in accordance with the work of[16][18]. It is clear from the data in table No.2 that significant 1000 grains weight was achieved by MP5 as compared to MP1, MP2 and MP3 while with MP4 it got at par result. Similarly MP4 also obtained significant 1000 grain weight as compared to MP2 and MP3 and at par weight with MP1. Similar investigations conducted by[16][18] reported comparable results and the findings of[19] are also consistent with this study. Table No.2 also showed that MP5 produced significantly better results compared to MP1 and MP3 for tillers m^{-2} while its performance was comparable to MP4 and MP2. Similar outcomes were reported by[16][18], and consistent findings were also noted by[19].

The Table No.3 revealed that for biological yield, MP5 showed the highest significant result of all the treatments except MP3 to which it was at par. These results were supported by research work of[19]. Table No.3 showed that MP5 is significant to all the treatments with regard of yield ha^{-1}. These results are consistent with the study conducted by[16] and comparable outcomes were observed in the research of [18]. Table No.3 revealed that harvest index vide MP5 outperformed MP1 and MP3 significantly, while showing results similar to MP2 and MP4. This observation aligns with the findings of[18]

Conclusion:

It was concluded on the basis of two years research that the highest significant grain yield, biological yield, 1000 grain weight, grain $spike^{-1}$, tillers m^{-2}, spike m^{-2}, plant height were noted when Phosphorus was placed by drill on both sides of the crop row. The 2nd most encouraging result was recorded for the method of placing by drill on one side of the crop row. So, application of Phosphorus by placing it on both sides of the row is recommended to get the highest yield of wheat. Moreover, by following this method, not only the efficiency of Phosphorus is increased but also fixation of Phosphorus with soil particles is minimized and food security problem will be solved to a greater extent. These findings will assist farming community to use the most suitable method of Phosphorus application and update their production technology. Moreover, by applying results of this research plant breeders will evolve and develop genotypes of wheat with great potential.

Authors, contributions:

A Quddoos & K Mahmood conceived and framed the trials: A Quddoos conducted trials:

K Mahmood & M Farooq performed the data analysis: A Quddoos & M Farooq searched materials / analysis/ tools: A Quddoos & K Mahmood wrote the paper: Alamgir Khan and Waqar Ahmad did the overall analysis and proof reading.

References:

[1] A. Rebi *et al.*, "Phosphorus Availability In Soil And Uptake By Maize From Rock Phosphate Inoculated With PGPR: A Review," *NVEO - Nat. VOLATILES Essent. OILS J. | NVEO*, vol. 9, no. 1, pp. 341–355, Feb. 2022, Accessed: Oct. 20, 2025. [Online]. Available: https://www.nveo.org/index.php/journal/article/view/4499

[2] A. Rebi *et al.*, "Soil ecology and possible and possible effects of soil texture microbial

assisted Co2 sequestration," *NVEO - Nat. VOLATILES Essent. OILS J. | NVEO*, vol. 8, no. 5, pp. 7458–7480, Nov. 2021, Accessed: Oct. 20, 2025. [Online]. Available: https://www.nveo.org/index.php/journal/article/view/1985

[3] M. A. R. G. Y. M. Z. M. A. M. N. R. K. S. N. M. N. H. M. I. A. A. A. A. R. Arshad Mahmood, "Effect Of Global Change And Possible Ways To Reduce Its Adverse Impact On Agriculture In The Overall World: A Review," *NVEO - Nat. VOLATILES Essent. OILS J. | NVEO*, pp. 16252–16278, Dec. 2021, Accessed: Oct. 20, 2025. [Online]. Available: https://www.nveo.org/index.php/journal/article/view/4339

[4] O. Farooq *et al.*, "Impact Of Sowing Time And Planting Method On The Quality Traits Of Wheat," *Innov. Agric. Soc. Sci*, vol. 3, no. 1, pp. 2311–3839, 2015, doi: 10.17957/JGIASS/3.1.676.

[5] I. Hussain, H. B. Ahmad, S. Rauf, M. Aslam, and A. M. Aulakh, "Effect of sowing time on quality attributes of wheat grain," *Int. J. Biosci*, 2015, doi: 10.12692/ijb/6.12.1-8.

[6] Nikos Alexandratos and Jelle Bruinsma, "WORLD AGRICULTURE TOWARDS 2030/2050 The 2012 Revision," *FAO Agric. Dev. Econ. Div.*, 2012, [Online]. Available: https://www.fao.org/4/ap106e/ap106e.pdf

[7] M. van Dijk, T. Morley, M. L. Rau, and Y. Saghai, "A meta-analysis of projected global food demand and population at risk of hunger for the period 2010–2050," *Nat. Food*, vol. 2, no. 7, pp. 494–501, Jul. 2021, doi: 10.1038/S43016-021-00322-9;SUBJMETA.

[8] D. A. Eitelberg, J. van Vliet, and P. H. Verburg, "A review of global potentially available cropland estimates and their consequences for model-based assessments," *Glob. Chang. Biol.*, vol. 21, no. 3, pp. 1236–1248, Mar. 2015, doi: 10.1111/GCB.12733.

[9] FAO, "The Future of Food and Agriculture—Trends and Challenges," *Annu. Rep.*, vol. 296, 2017, [Online]. Available: https://www.scirp.org/reference/referencespapers?referenceid=3718800

[10] D. Gerten *et al.*, "Feeding ten billion people is possible within four terrestrial planetary boundaries," *Nat. Sustain.*, vol. 3, no. 3, p. 200, Mar. 2020, doi: 10.1038/s41893-019-0465-1.

[11] A. K. Wahid, F., M. Sharif, M.A. Khan, A. Ali, "Addition of rock phosphate to different organic fertilizers influences phosphorus uptake and wheat yield," *Researchgate.Net*, vol. 30, no. 3, pp. 90–100, 2015, Accessed: Oct. 20, 2025. [Online]. Available: https://www.academia.edu/11839346/Addition_Of_Rock_Phosphate_To_Different_Organic_Fertilizers_Influences_Phosphorus_Uptake_And_Wheat_Yield

[12] A. Rehim, M. Farooq, A. ‡ And, and M. Hussain, "Band Placement of Phosphorus Improves the Phosphorus Use Efficiency and Wheat Productivity under Different Irrigation Regimes," *Int. J. Agric. Biol. Int. J. Agric. Biol*, vol. 14, pp. 727–733, 2012, Accessed: Oct. 20, 2025. [Online]. Available: http://www.fspublishers.org

[13] A. Jamal and M. Fawad, "Effectiveness of Phosphorous Fertilizers in Wheat Crop Production in Pakistan," *J. Hortic. Plant Res.*, vol. 5, pp. 25–29, Jan. 2019, doi: 10.18052/WWW.SCIPRESS.COM/JHPR.5.25.

[14] M. A. Miguel, J. A. Postma, and J. P. Lynch, "Phene Synergism between Root Hair Length and Basal Root Growth Angle for Phosphorus Acquisition," *Plant Physiol.*, vol. 167, no. 4, pp. 1430–1439, Mar. 2015, doi: 10.1104/PP.15.00145.

[15] A. R. Sharma, "Fertiliser management in maize-wheat cropping system in the Western Himalayan Region," *Fertil. News*, vol. 49, no. 2, pp. 13–32, 2004, [Online]. Available: https://www.cabidigitallibrary.org/doi/full/10.5555/20043060548

[16] Z. Iqbal* and M. A. and R. A. , Muhammad Yaqub, "Phosphorus fertigation: A technique for enhancing P fertilizer efficiency and yield of wheat and maize," *Soil Environ.*, vol. 32, no. 2, pp. 146–151, 2013, [Online]. Available: https://www.researchgate.net/profile/Zafar-Iqbal-10/publication/286704633_Phosphorus_fertigation_A_technique_for_enhancing_P_fertilizer_efficiency_and_yield_of_wheat_and_maize/links/5a0bb4b8458515e48274c55a/Phosphorus-fertigation-A-technique-for-enhancing

[17] A. Rehim *et al.*, "Band-application of phosphorus with farm manure improves phosphorus use efficiency, productivity, and net returns of wheat on sandy clay loam soil," *Turkish J. Agric. For.*, vol. 40, no. 3, pp. 319–326, Jan. 2016, doi: 10.3906/tar-1505-133.

[18] S. Noonari *et al.*, "Effect of Different Levels of Phosphorus and Method of Application on the Growth and Yield of Wheat," *Nat. Sci.*, vol. 8, no. 7, pp. 305–314, Jul. 2016, doi: 10.4236/NS.2016.87035.

[19] P. S. Renjith, d. Kumar, Y. S. SHIVAY, and K. R. SHEETAL, "Effect of different phosphorus levels and application methods on growth, productivity and economics of wheat (Triticum aestivum L.)," *J. Crop Weed*, vol. 16, no. 3, pp. 187–197, Jan. 2020, doi: 10.22271/09746315.2020.V16.I3.1386.