E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; 7(4): 05-08
Received: 08-01-2024
Accepted: 12-02-2024

Yagini Tekam
Department of Soil Science, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

BK Dixit
Department of Soil Science, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

BS Dwivedi
Department of Soil Science, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

Risikesh Thakur
College of Agriculture, Balaghat, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Madhya Pradesh, India

Alpana Kumhare
Department of Agronomy, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

Abhisek Sharma
Department of Soil Science, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

Corresponding Author:
Risikesh Thakur
College of Agriculture, Balaghat, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Madhya Pradesh, India

Impact of long-term application of inorganic fertilizers and organic manure on wheat yield and available phosphorous contents in a vertisol under soybean-wheat cropping sequence

Yagini Tekam, BK Dixit, BS Dwivedi, Risikesh Thakur, Alpana Kumhare and Abhisek Sharma

DOI: https://doi.org/10.33545/2618060X.2024.v7.i4a.506

Abstract
Long-term fertilizer treatments may affects the available phosphorus status of soil. Therefore, a field experiment was conducted during 2021-22 under All India Coordinated Research Project on Long-Term Fertilizer Experiment (AICRP on LTFE) at Research Farm, Department of Soil Science and Agricultural Chemistry, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (Madhya Pradesh) – India, to evaluate the availability of phosphorous in a Vertisol under soybean – wheat cropping system. The experiment was laid out in randomized block design with eight treatments comprising four replications. The treatments were performed in conjunction with different fertilizer doses, viz 50% NPK, 100% NPK, 150% NPK, 100% N, 100% NP, 100% NPK+FYM, 100% NPK-S and control. The results of the present study revealed that the application of 100% NPK+FYM treatment was found the yield of wheat (grain & straw) and available P status in soil, followed 150% NPK treatments. However, the lowest yield and available P status were observed in control plot, followed by 100% N alone treatment. The findings further revealed that the appreciable increase in available P status in soil in all the treatments except control and 100% N alone treatments. Thus, the balance dose of fertilizer applications, either alone or in combination with organic manure is required to sustainable crop production and augmenting soil fertility status.

Keywords: Phosphorus, wheat, inorganic fertilizers, FYM, vertisols, etc.

Introduction
Phosphorus (P) element is an essential for maintaining soil fertility and augmenting crop yields in Indian soils. Out of 17 necessary plant nutrients, phosphorus is next to nitrogen in terms of crop yield. It is one of the important key elements for plant growth. The amount of P that is contained in soil that is usable by plants is very small. The characteristics associated with phosphorus nutrition include crop quality, resistance to plant diseases, root development, stalk and stem strength, flower and seed formation, crop maturity and production, N-fixation in legumes, and crop quality. Phosphorus could be a major growth-limiting nutrient compared to nitrogen, there is no large atmospheric source that will be made biologically available [1, 2]. Soils are also known to vary widely in their capacity to supply phosphorus to plants. Only a small fraction of total P in soil is found in plant available form. In black soils, a major part of the applied phosphorus gets fixed (80-85%) and only a small part (15-20%) of it becomes available to the plants [3]. The phosphorous availability in soil is governed by several factors like, soil pH, moisture, Ca content, applied nutrients, etc [4].
The most important input for raising agricultural yield is fertilizer, yet excessive and continuous application of fertilizer degrades soil fertility. Many studies have revealed that long-term continuous application of fertilizers or manures increases soil P mobility. This is helpful in resolving the complex problems of the management of soil fertility. The continuous application of inorganic fertilizers over time appears to have the potential to significantly reduce soil fertility [5, 6]. The combined application of inorganic fertilizers with organic manures can not only sustain crop yields but also effectively improve soil health and increase nutrient usage efficiency.

The long-term fertilizer experiment has been conducted for five decades; major attention has been paid to the yield performance of crops and the relative efficiency of manure and fertilizer. In a permanent manorial experiment, cropping kinds and doses of fertilizer, as well as the nature of the soil (i.e., P-fixing capacity and phosphate potential), determine the response of phosphatic fertilizer in terms of its transformation, translocation, and build-up proportion of the total and available P status of the soil [7, 8]. Thus, the present study was undertaken to find out the long term application of fertilizers and organic manure on wheat yields and phosphorous availability in Vertisols under soybean – wheat cropping system.

Materials and Methods

Experimental Details

The present research is part of the All India Coordinated Research Project on a Long-Term Fertiliser Experiment under Soybean-Wheat Cropping Sequence in a Vertisol, which was initiated in 1972 at Research Farm, Department of Soil Science, Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur, Madhya Pradesh, India. The experimental site has a semi-arid and sub-tropical climate with a typical dry summer and cold winter. It is situated 393 metres above mean sea level at 23°10 N latitude and 79°57′E longitude. The total rainfall per year varies from 1000 to 1500 mm, with a mean of approximately 1350 mm. The experimental soil belongs to medium black of Kheri series with fine montmorillonitic hyperthermic soils, Typic Haplustert (Vertisol). The basic soil properties (0-15 cm soil depth) before start of the experiment in the year 1972 are presented in Table 1. The experiment was conducted and designed in a randomized block design with eight treatments and four replications. A permanent bund was used to divide each individual plot (17.0 m × 10.8 m), and a gap of 2.0 m was used to divide two blocks. The 100% optimal NPK doses based on initial (1972) soil test values were 20:80:20 and 120:80:40 kg NPK ha^{-1} for soybean and wheat, respectively. The treatment details and quantity of nutrients added are presented in Table 2.

Table 1: Basic soil properties of the experimental site (1972)

S. No.	Soil properties	Value
1.	$pH_{1:2.5}$	7.60
2.	Electrical conductivity ($EC_{1:2.5}$)	0.18 dSm^{-1}
3.	Soil organic carbon	5.7 g kg^{-1}
4.	Calcium carbonate	4.6%
5.	Soil available nitrogen (N)	193 kg ha^{-1}
6.	Soil available phosphorus (P)	7.60 kg ha^{-1}
7.	Soil available potassium (K)	370 kg ha^{-1}
8.	Soil available sulphur (S)	7.80 mg kg^{-1}
9.	Soil available zinc (Zn)	0.33 mg kg^{-1}

Table 2: Details of treatment and nutrient rates (kg ha^{-1}) in soybean and wheat

Treatments	Fertilizer nutrients applied (kg ha^{-1})					
	Soybean			Wheat		
	N	P	K	N	P	K
50% NPK	10	17.6	8.3	60	17.6	16.6
100% NPK	20	35.2	16.6	120	35.2	33.2
150% NPK	30	52.8	24.9	180	52.8	49.8
100%NP	20	35.2	NA	120	35.2	NA
100% N	20	NA	NA	120	NA	NA
100% NPK+FYM*	46.5	41.8	42.7	120	35.2	33.2
100% NPK (-S)	20	35.2	16.6	120	35.2	33.2
Control	NA	NA	NA	NA	NA	NA

NPK: The percent amount of Nitrogen (N), Phosphorous (P) and Potassium (K) applied through inorganic fertilizers

*FYM contains 0.53% N, 0.30% P_2O_5& 0.63% K_2O; NA: Not Applied

The sources of nitrogen (N), phosphorus (P) and potassium (K) which were applied included urea, single superphosphate (SSP) and muriate of potash (MOP). In 100% NPK (-S) treatment, diammonium phosphate (DAP) was used instead of SSP as a source of phosphorus. The farmyard manure (FYM) was applied at the rate of 5 t ha^{-1} yr^{-1} to soybean crop only during kharif season just 10-15 days before sowing. In soybean crop, all NPK fertilizers were applied as basal before the last harrowing during rainy season, however, in wheat crop 50% N and 100% PK was applied as basal before sowing and rest 50% N in two split applications, first half at 21–25 days (following the first irrigation) and the second half at 51–55 days.

Soil and Plant Analysis

For the present study, soil samples were collected during 2021-22 from different treatment plots at 0-15 cm soil depth. Composite soil samples were air-dried at room temperature, pulverized, and sieved through a 2.0 mm sieve. The phosphorus content in soil was extracted with 0.5 M $NaHCO_3$ (pH 8.5) solution as described by [9]. However, to calculate wheat yields (grain and straw) in each plot, an area of 5 × 4 m^2 was harvested. After complete air drying, the bundles were weighed and data recorded. The produce was threshed after that grain and straw yields of wheat were recorded.

Statistical Analysis

The data pertaining to available P contents and wheat yields (grain and straw) were statistically analyzed using analysis of variance (ANOVA) for randomized block design taking eight treatments with four replications to draw suitable inferences as per standard method described by [10].

Results and Discussion

Available Phosphorus

The data depicted in Fig. 1 indicated that the available phosphorus differed significantly over control due to the influence of various treatments under long-term application of fertilizers and manure. All the treatments performed significantly higher available P status as compared to control and 100% N alone treatments. The amount of available phosphorus at 0-15 cm soil depth was gradually increased with increasing fertilizer levels *i.e.* 50% NPK, 100% NPK and 150% NPK. The highest value of available P in soil was found under treatment application with 100% NPK+ FYM, which was at par with 150% NPK at 0-15 cm and 15-30 cm soil depths. The addition of phosphorus through fertilizers and organic manures were responsible for of the increase in available P in the soils. Nutrient mobility, solubility, and availability were increased by nutrient complexing substances like fulvic and humic acids, which are produced during the breakdown of organic manures. Similar findings were also reported by [11, 12, 13].

However, the imbalance use of fertilizers reduced the available P status of soil. A significant reduction in available P content was noted in 100% N alone and control treatments; this is due to the removal of P by the crops in the absence of P supplementation through an external source. The use of 100% NP over 100% N alone significantly increased the available P status of soil. Further, the application of 100% NPK over 100% NP had no significant effect on available P status. Further, the results of the present study revealed that the highest available P content was observed in 0-15 cm soil depth as compared to 15-30 cm soil depth in all the treatments [14, 15].

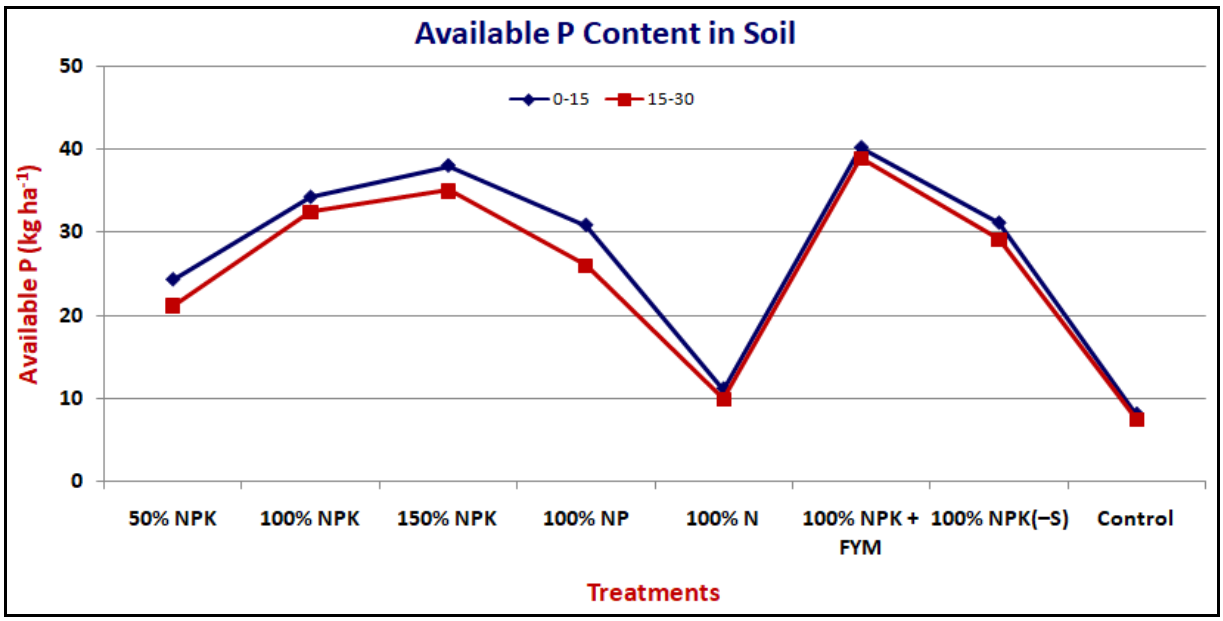

Fig 1: Impact of long-term application of fertilizers and manure on available P contents at 0-15 cm and 15-30 cm soil depth.

Grain and Straw Yield of Wheat

The grain and straw yields of wheat are illustrated in Fig. 2 and found that the lowest grain and straw yields of wheat 1460 and 4223 kg ha^{-1}, respectively, were recorded in the control plot and followed by 1850 and 5425 kg ha^{-1}, respectively in 100% N alone treatments. Similar results also showed by [16, 17]. However, grain and straw yields of wheat crop were found in 100% NPK + FYM treatment (6150 and 6860 kg ha^{-1}, respectively) was significantly higher than 100% NPK treatment. 150% NPK treatment was found to be at par with the application of 100% NPK + FYM while, inclusion of K along with NP (100% NPK) caused an increase of around 26.3 % over application of 100% NP alone in wheat. Instead of applying 150% NPK, it is better to use FYM with 100% NPK [18, 19] since the yields obtained with 100% NPK+FYM are superior to 150% NPK application. The beneficial effect of FYM can be due to a steady supply of all nutrients, including the micronutrients and improvements in physical condition. The similar beneficial effects of FYM along with NPK have been reported by [20, 21, 22]. They observed that the continuous use of chemical fertilizers applied either singly or in combination with FYM had a marked effect on grain yield.

The data pertaining to grain and straw yields of wheat have also been indicated that the imbalance use of chemical fertilizers caused total degradation of soil health which was also reflected in reduction of crop yields [23, 24, 25]. Continuous application of N alone resulted in an increase in yield over control but the response exhibited a decline trend with time due to imbalance use of nutrients supply [26, 27]. FYM with 100% NPK application was beneficial for all crops of the rotation. This indicated the significant positive role of farmyard manure application in improving the overall soil environment. Similar results were reported by [28].

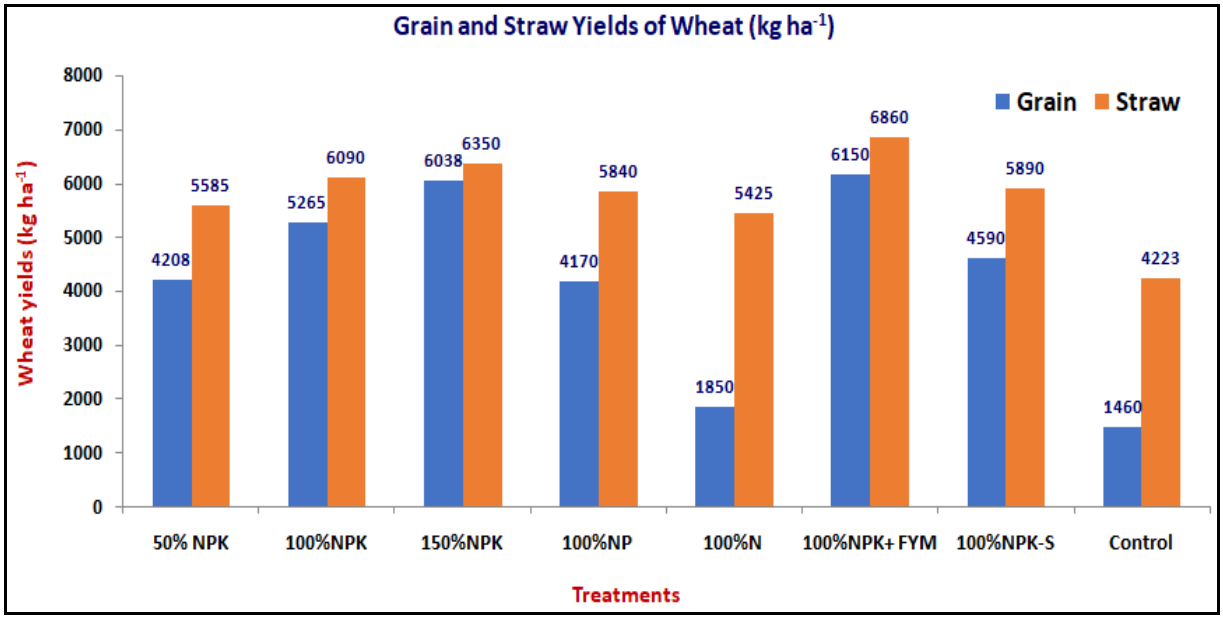

Fig 2: Impact of long-term application of fertilizers and manure on wheat yields

Conclusion

From the present investigation, it may be concluded that the balanced application of inorganic fertilizers either alone or in combination with organic manure sustained wheat yield and

phosphorous availability, however, imbalance use of nutrients reduced wheat yield and phosphorous availability in Vertisols under soybean-wheat cropping system. Thus, the balanced fertilizer application with or without organic manure not only sustained crop productivity but also improved phosphorous availability over a long period of five decades.

References

1. Bairwa J, Dwivedi BS, Rawat A, Thakur RK, Mahawar N. Long-term effect of nutrient management on soil microbial properties and nitrogen fixation in a Vertisol under soybean–wheat cropping sequence. J Indian Soc Soil Sci. 2021;69(2):171-178.
2. Bagde V, Dwivedi BS, Dwivedi AK, Thakur R, Nagwanshi A. Effect of Long-Term Fertilizer and Farm yard Manure Application on Soil Phosphorus Fractions in a Vertisol under Soybean–Wheat Cropping Sequence. J Indian Soc Soil Sci. 2023;71:207-216.
3. Dubey L, Dwivedi BS, Dwivedi AK, Thakur RK. Effect of long term application of fertilizers and manure on profile distribution of various phosphorus fractions in Vertisol. Green Farming. 2016;7(2):365-370.
4. Dwivedi AK, Dwivedi BS. Impact of long term fertilizer management for sustainable soil health and crop productivity: Issues and challenges. JNKVV Res J. 2015;49:387-397.
5. Sawarkar SD, Singh M, Khamparia NK, Wanjari RH, Thakur R. Research Bulletin on Long Term Impact of Fertilizer and Manure on Soil Quality, Crop Productivity and Sustainability under Soybean-Wheat System in Vertisol. ICAR–Indian Institute of Soil Science, Bhopal. 2015:1-63.
6. Thakur RK, Bisen NK, Shrivastava AK, Rai SK, Sarvade S. Impact of Integrated Nutrient Management on Crop Productivity and Soil Fertility under Rice (*Oryza sativa*) – Chickpea (*Cicer arietinum*) Cropping System in Chhattisgarh Plain Agro-Climatic Zone. Indian J Agron. 2023;68(1):9-13.
7. Thakur R, Kauraw DL, Singh M. Effect of continuous applications of nutrient inputs on spatial changes of soil physicochemical properties of a medium black soil. J Soils Crops. 2009;19(1):14-20.
8. Thakur R, Sarvade S, Dwivedi BS. Heavy Metals: Soil Contamination and Its Remediation. AATCC Rev. 2022;10(02):59-76.
9. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. US Department of Agriculture Circular. 1954;939.
10. Gomez KA, Gomez AA. Statistical procedures for agricultural research. John Wiley & Sons; c1984.
11. Thakur R, Sawarkar SD, Kauraw DL, Singh M. Effect of Inorganic and Organic Sources on Nutrients Availability in a Verisol. Agropedology. 2010;20(1):53-59.
12. Birla K, Khamparia NK, Thakur RK, Dwivedi BS, Sawarkar SD. Profile Distribution of Various Fractions of Sulphur as Influenced by Long Term Application of Fertilizers and Manure in Vertisol. Green Farming. 2015;6(4):753-756.
13. Munia A, Dixit BK, Tripathi PN, Gupta V, Tekam Y, Meravi A, Damor JS. Impact of Long – term use of Fertilizers and Manure on Distribution of Soil – inorganic Phosphorus Fractions in a Vertisol. Int J Environ Clim Change. 2023;13(11):2731-2741.
14. Nagwanshi A, Dwivedi AK, Dwivedi BS, Anupama K. Effect of long term application of fertilizer and manure on soil properties of a Vertisol in soybean-wheat cropping sequence. Int J Chem Stud. 2018;6:2946-2949.
15. Dwivedi BS, Sharma A, Dwivedi AK, Thakur RK. Response of Phosphorus Application on Productivity of Wheat at Farmer Field. Univ J Agric Res. 2019;7(1):20-24.
16. Khandagle A, Dwivedi BS, Aher SB, Dwivedi AK, Yashona DS, Jat D. Effect of long term application of fertilizers and manure on soil properties. J Soils Crops. 2019;29(1):97-104.
17. Tiwari R, Dwivedi BS, Sharma YM, Thakur R, Sharma A, Nagwanshi A. Soil Properties and Soybean Yield as Influenced by Long Term Fertilizer and Organic Manure Application in a Vertisol under Soybean-Wheat Cropping Sequence. Legume Res; c2023. DOI: 10.18805/LR-5111.
18. Kushwaha S, Sawarkar SD, Thakur R, Khamparia NK, Singh M. Impact of long-term nutrient management on soil nitrogen dynamics under soybean – wheat cropping sequence on a Vertisol. J Indian Soc Soil Sci. 2017;65:274-282.
19. Gupta A, Dwivedi AK, Nagwanshi A, Dwivedi BS, Vishwakarma AK. Impact of Long Term Application of Inorganic Fertilizer and Farm Yard Manure on Productivity of Soybean in Vertisol. Bull Environ Pharmacol Life Sci. 2019;8(4):116-132.
20. Pathariya P, Dwivedi BS, Dwivedi AK, Thakur RK, Singh M, Sarvade S. Potassium Balance under Soybean–wheat Cropping System in a 44 Year Old Long Term Fertilizer Experiment on a Vertisol. Commun Soil Sci Plant Anal. 2022;53(2):214-226.
21. Jarupula S, Dwivedi BS, Dwivedi AK, Pandey SK. Effect of long term application of nitrogen and sulphur nutrition on nitrogen assimilation in Soybean. J Pharmacogn Phytochem. 2018;7(1):2000-2004.
22. Parihar SK, Dwivedi BS, Khan IM, Tiwari RK. Effect of integrated nutrient management on yield and economics of little millet (*Panicum sumatrense* Roth. Ex Roem. and Schult.). J Soils Crops. 2010;20(2):211-215.
23. Panwar S, Dwivedi AK, Dwivedi BS, Nagwanshi A. Distribution of zinc pools as influenced by long-term application of fertilizers and manure in a Vertisol. Int J Chem Stud. 2017;5(6):1931-1934.
24. Patel G, Dwivedi BS, Dwivedi AK, Thakur R, Singh M. Long-term Effect of Nutrient Management on Soil Biochemical Properties in a Vertisol under Soybean–Wheat Cropping Sequence. J Indian Soc Soil Sci. 2018;66(2):215-221.
25. Tiwari RK, Dwivedi BS, Deshmukh G, Pandey AK, Jha AK. Effect of weed control treatments on growth of little seed canary grass and productivity of wheat. Indian J Weed Sci. 2011;43(3&4):239-240.
26. Khatik SK, Thakur R, Sharma GD. Lead: The Heavy Metal in Soil, Water and Plant Environment. J Ind Pollut Control. 2006;22(2):233–244.
27. Meshram MK, Dwivedi BS, Naik KR, Thakur RK, Keram KS. Impact of organic and inorganic sources of nutrients on yield, nutrient uptake, soil fertility and economic performance of rice in a Typic Haplustert. J Soils Crops. 2018;28(1):31-36.
28. Sharma YM, Jatav RC, Sharma GD, Thakur R. Status of Micronutrients in Mixed Red and Black Soils of Rewa District of Madhya Pradesh, India. Asian J Chem. 2013;25(6):3109-3112.