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KishanIwnati
Department of Soil Science and Agricultural Chemistry, A.K.S. University, Satna, Madhya Pradesh, India

Atul Kumar Singh
Assistant Professor, Department of Soil Science and Agricultural Chemistry, A.K.S. University, Satna, Madhya Pradesh, India

Corresponding Author:
KishanIwnati
Department of Soil Science and Agricultural Chemistry, A.K.S. University, Satna, Madhya Pradesh, India

Effect of inorganic phosphorus levels on yield and uptake of Nutrients in late-sown wheat (*Triticum aestivum* L.) crop

KishanIwnati and Atul Kumar Singh

Abstract
A field experiment was conducted during *rabi* season of 2022-23 at the Research Farm, A.K.S. University, Satna (M.P.) to study the effect of phosphorus levels on yield and uptake of nutrients in late-sown wheat. Amongst the application of increasing levels of inorganic phosphorus up to 90 or 100 kg/ha increased the yield-attributes, crop productivity, NPK nutrient contents in grain and straw as well as their total uptake per hectare by wheat var. JW-3336. The grain yield of wheat under 100 kg P_2O_5/ha was 35.53 q/ha, straw yield 53.72 q/ha and total N, P, K uptake was 127.75, 20.96 and 105.47 kg/ha, respectively. It may be inferred from the results that the application of inorganic phosphorus up to 90 kg/ha was found optimum in increasing the residual status of available N, P and K in soil besides crop yield and uptake of nutrients by the wheat crop.

Key words: Phosphorus, uptake, nutrients, late-sown wheat

Introduction
Soil fertility and crop productivity are closely related to three main components of soil ecosystems: the bio-available soil nutrients, soil microbiota and organic matter content. Phosphorus is the second most yield limiting nutrient after nitrogen in agricultural production across the world. Phosphorus plays many key functions in plant life especially in the storage and transfer of energy, photosynthesis, respiration, cell division and enlargement. Application of phosphatic fertilizers in a balanced amount and at the correct time with good application techniques and management methods has good impacts on crop yield. However, responses to fertilization can be species and variety dependent, which greatly influences nutrient accumulation and utilization in the plant. (Singh *et al*., 2017) [9].
Phosphorus deficiency is often a yield-limiting factor in agricultural soils, particularly in those having high carbonate contents, which reduces phosphorus solubility. In these conditions, achieving target crop productivity generally demands the use of higher fertilizer rates a way to account for increased fertilizer efficiency (Mishra *et al*., 2017) [3].
Wheat is one of the most popular cereal crops in India as it is a staple food for human consumption. Wheat is usually grown in *Rabi* season. The productivity of wheat is low due to low status of phosphorus in soil and its inadequate supply. The phosphorus nutrient when applied to cereal enhances root and shoot growth and ultimately the wheat yield. Recently developed varieties also increases the yield of wheat. The lack of information about the proper dose of phosphorus addition to well-promising wheat varieties have motivated to generate information for the wheat growers of Kymore plateau of Madhya Pradesh.

Materials and Methods
The field experiment was carried out during *rabi* season of 2022-23 at the Research Form, A.K.S. University Satna (M.P.). The soil of the experimental field was silty clay-loam having pH 7.45, electrical conductivity 0.25 dS/m, organic carbon 0.47%,available N, P_2O_5 and K_2O 194.3, 13.2 and 221.0 kg/ha, respectively. The total rainfall received during winter season was 10.42 mm. There were 10 different inorganic phosphorus levels (20 to 100 kg/ha with a control) which were laid out in a randomized-block design keeping three replications. The JW-3336 variety of wheat was sown @ 120 kg seed/ha in rows 20 cm apart on 24th October, 2022. The common dose of 60 kg N and 40 kg K_2O was applied in all the treatments. The P-levels were applied through single superphosphate. The crop was grown as per recommended package of practices. The crop was harvested on 9th April, 2023.

The growth, yield attributes and yield were recorded at harvest. The N, P and K contents in seed and straw were analysed by adopting standard analytical procedures (A.O.A.C., 1997) [1]. The nutrients uptake per hectare was calculated by multiplying the seed or straw yield with the per cent nutrient content in seed or straw. The initial as well as residual available N, P_2O_5 and K_2O were determined by following the prescribed analytical procedures.

Results and Discussion

Yield parameters

The scrutiny of data in Table 1 reveal that the application of phosphorus up to 100 kg/ha enhanced significantly the grain and straw yield over lower doses (Table 2). The equally maximum grain yield (35.53 to 35.66 q/ha) and straw yield (52.65 to 53.72 q/ha) was recorded with 90 and 100 kg P_2O_5/ha. The grain and straw yield was followed by 90, 70and 60 kg P_2O_5/ha. The higher yields with increasing levels of phosphorus was mainly due to adequate supply of phosphorus to plants which is turn contributed to better growth and yield attributes, thus led to higher yield. Application of 20 kg P_2O_5/ha gave the lowest yield due to poor growth, metabolic processes and yield attributes. Similar findings was reported by Rasul *et al.* (2016) [5], Mishra *et al.*, (2017) [3], Goswami and Pandey (2018) [2] and Shafi *et al.* (2020) [8].

Uptake of nutrients

Phosphorus uptake by grain and straw of wheat is collectively known as total phosphorus uptake by wheat plants. The amount of total P-uptake by wheat depends upon the production level, amount of applied P and the soil type (Saha *et al.*, 2014) [6].

The uptake of N, P and K by grain and straw increased significantly with increasing phosphorus levels up to 100 kg/ha (Table 1). Thus, the maximum uptake of N by grain (81.0 – 81.3 kg/ha) and by straw (45.28 – 46.74 kg/ha), P-uptake by grain (12.79 – 12.84 kg/ha) and by straw (7.79 to 8.11 kg/ha), and K-uptake by grain (21.0 to 21.67 kg/ha) and by straw (81.61 to 83.80 kg/ha) was recorded with 90 to 100 kg P_2O_5/ha. This was followed by 80, 70, 60 and so on up to zero kgP_2O_5/ha, Accordingly under without phosphorus, the N uptake in grain and straw was 45.53 and 24.49 kg/ha, P uptake 4.92 and 4.38 kg/ha, Similarly, K uptake in grain and straw was 12.60 and 49.83 kg/ha, respectively.

The improvement in uptake of N, P and K by grain and straw due to increased application of phosphorus was mainly attributed the fact that increased addition of phosphorus increased the N, P and K content in grain and straw by providing balanced nutritional environment inside the plant and higher photosynthesis efficiency which favoured the growth and crop yield (Table 1). Thus, the higher nutrients uptake with increasing P-levels was mainly due to improved content of N, P and K coupled with higher grain and straw yield resulted higher uptake of nutrients per hectare. The increase in uptake of nutrients with P-fertilization was also reported by Septa and Rai (2013) [7], Saha *et al.* (2014) [6] and Shafi *et al.* (2020) [8].

Changes in residual soil properties

The data in Table 2 indicate that **t**he application of increasing doses of inorganic phosphorus from 20 to 100 kg/ha increased the available-N in post-harvest soil (193.8 to 203.4 kg/ha) as compared to initial status (189 kg/ha). It is attributed to enhanced root-shoot growth, mineralization of organic portion in soil rhizosphere which might have helped to build up of higher available-N Yaduvanshi *et al.* (2013) [10] and Mukesh Kumar *et al.* (2015) [4]. Similarly the available-P content of the post-harvest soil increased with the increasing levels of applied phosphorus up to 100 kg/ha (13.6 to 18.3 kg/ha available-P). This was as compared to 12.3 kg P_2O_5/ha in the initial soil status. The increase in P status to soil due to addition of phosphorus levels can be attributed to the increased levels of applied phosphorus for plant growth and development. The results confirm to the findings of Yaduvanshi *et al.* (2013) [10] and Mukesh Kumar *et al.* (2015) [4]. The similar results trend was also noticed in case of available-K in the post-harvest soil. The increasing levels of inorganic phosphorus from20 kg up to 100 kg/ha increased the available-K content in the post-harvest soil (222.6to 228.4 kg/ha). Whereas the available-K content in the soil before sowing of the crop was 217.5 kg/ha. The higher doses of applied phosphorus from 20 up to 100 kg/ha increased the available-K content in the post-harvest soil (222.6 to 228.4 kg/ha) as compared to its initial soil status (217.5 kg/ha). This might be as a result of increased organic matter addition from residues of increased root growth and development. Similar results have also been reported by Septa and Rai (2013) [7] and Mukesh Kumar *et al.* (2015) [4].

Table 1: Yield and nutrients uptake of wheat var. JW-3336 as influenced by phosphorus levels

S. No.	Treatments	Grain yield (q/ha)	Straw yield (q/ha)	N-uptake (kg/ha			P-uptake (kg/ha			K-uptake (kg/ha		
				Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T_1	Control	25.87	42.96	45.53	24.49	70.02	4.92	4.38	9.30	12.60	49.83	62.43
T_2	20 kg P_2O_5/ha	27.75	45.15	58.28	27.54	85.82	6.38	4.97	11.35	13.68	58.70	72.38
T_3	30 kg P_2O_5/ha	28.68	46.73	61.38	29.91	91.29	7.46	5.51	12.97	14.88	64.49	79.37
T_4	40 kg P_2O_5/ha	30.72	47.65	66.97	32.40	99.37	8.91	5.96	14.87	16.22	67.19	83.41
T_5	50 kg P_2O_5/ha	31.64	48.83	70.24	35.16	105.40	9.81	6.25	16.06	17.05	70.32	87.37
T_6	60 kg P_2O_5/ha	32.90	49.69	74.03	36.77	110.80	10.53	6.61	17.14	18.29	73.54	91.83
T_7	70 kg P_2O_5/ha	33.78	50.89	76.34	39.69	116.03	11.49	7.12	18.61	19.19	76.34	95.53
T_8	80 kg P_2O_5/ha	34.89	51.68	79.20	42.38	121.58	12.21	7.55	19.76	19.96	79.07	99.03
T_9	90 kg P_2O_5/ha	35.66	52.65	81.30	45.28	126.58	12.84	7.79	20.63	21.00	81.61	102.61
T_{10}	100 kg P_2O_5/ha	35.53	53.72	81.01	46.74	127.75	12.79	8.17	20.96	21.67	83.80	105.47
	S.Em+	0.49	0.60	0.86	0.92	1.78	0.012	0.03	0.015	0.015	0.94	0.96
	C.D. (P=0.05)	1.43	1.74	2050	2.67	5.17	0.035	0.09	0.044	0.043	2.73	2.77

Table 2: Residual soil properties after wheat harvest as influenced by inorganic phosphorus levels

S. No.	Treatments	Avail. N (kg/ha)		Avail. P (kg/ha)		Avail. K (kg/ha)	
		Before sowing	After harvest	Before sowing	After harvest	Before sowing	After harvest
T_1	Control	194.3	189.0	13.2	12.3	221.0	217.5
T_2	20 kg P_2O_5/ha	194.3	193.8	13.2	13.6	221.0	222.6
T_3	30 kg P_2O_5/ha	194.3	195.3	13.2	13.8	221.0	224.3
T_4	40 kg P_2O_5/ha	194.3	196.0	13.2	15.4	221.0	224.8
T_5	50 kg P_2O_5/ha	194.3	198.0	13.2	14.8	221.0	226.6
T_6	60 kg P_2O_5/ha	194.3	197.7	13.2	15.7	221.0	225.7
T_7	70 kg P_2O_5/ha	194.3	199.2	13.2	16.8	221.0	226.8
T_8	80 kg P_2O_5/ha	194.3	203.4	13.2	17.5	221.0	227.0
T_9	90 kg P_2O_5/ha	194.3	201.6	13.2	16.9	221.0	228.4
T_{10}	100 kg P_2O_5/ha	194.3	202.8	13.2	18.3	221.0	227.9
	S.Em+	-	0.27	-	0.007	-	0.91
	C.D. (P=0.05)	-	0.79	-	0.021	-	2.64

Conclusion

On the basis of results summarized above, the following specific conclusion are warranted.

Amongst the application of increasing levels of inorganic phosphorus upto 90 or 100 kg/ha increased the yield-attributes, crop productivity, NPK nutrient contents in grain and straw as well as their total uptake per hectare by wheat var. JW-3336. The wheat grain yield under P_{100} was 35.53 q/ha, straw yield 53.72 q/ha, total N, P, K uptake was 127.75, 20.96 and 105.47 kg/ha, respectively.

It may be inferred from the results that the application of inorganic phosphorus upto 90 kg/ha was found optimum in increasing the residual status of available N, P and K in soil besides crop yield and uptake of nutrients by the wheat crop.

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