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Effect of integrated phosphorus management on macronutrients availability and uptake by wheat (*Triticum aestivum* L.) under rained conditions of temperate Kashmir

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Abstract
Wheat (*Triticum aestivum* L.) belongs to family Poaceae and is extensively grown in China and India. In order to study the effect of integrated phosphorus management on macronutrients availability and uptake by wheat (*Triticum aestivum* L.) under rained conditions of temperate Kashmir, the present investigation was undertaken. The highest nutrient content (2.52, 0.31 and 2.86% N, P and K respectively) of wheat was obtained with the application of 80% Recommended Dose of Phosphorus (RDP) + 0.3 t vermicompost (V.C) ha^{-1} + Phosphorus Solubilizing Bacteria (PSB) through seed application + PSB through soil application (T_6). However, the highest N, P and K uptake (125.87, 19.46 and 147.00 kg ha^{-1}) of wheat was obtained with the application of 80 percent P through RDP + 0.3 tan V.C ha^{-1} + PSB through seed + PSB through soil (T_6).

Keywords: Wheat, nutrient content and uptake

Introduction
Wheat (*Triticum aestivum* L.) has been described as “Staff of life or king of cereals” and one of the most important staple food crop of India. Wheat is cultivated in at least 63 countries of the world. The leading countries in wheat cultivation are China, India, Russia, U.S.A and Canada (IWPS, 2022). Total world production of wheat was 772 million tons an on area of 218 million hectares with a productivity of 2960 kg ha^{-1}.

The global population is expected to double within the next generation, becoming the task more difficult for food security. This is likely to be more complicated by environmental problems due to the intensive use of chemicals. Therefore, the sustainability of agricultural production is a question of major concern for the race because agriculture is the prime source of food. In modern agriculture, ever increasing use of fertilizers without adequate organic recycling has not only aggravated multinutrient deficiencies in soil plant system but also deteriorated soil productivity and created environmental pollution. The concept of integrated nutrient management gaining importance. Hence integrated use of chemical source of nutrient along with crop residue, compost, biofertiliser, green manures and agricultural waste is essential. Integrated nutrient management involves the judicious blend of organic, inorganic fertilizers along with biofertiliser which maintains soil fertility, productivity, and ultimately causes a significant reduction in chemical fertilizers which is cost effective. The aim is ecologically safety exploitation of local resources which can produce desired yield and maintained soil health on long term basis (Kumarswamy, 2001) [16]. Increase in the deterioration of soil health and productivity due to continuous use of large quantities of chemical fertilizers, resulting environmental pollution and concern for sustainable agriculture with emphasis on eco-friendly inputs have resulted in the renewed interest on integrated plant nutrient supply systems. The basic concept underlying the integrated plant nutrient supply system is the maintenance of soil fertility, sustaining agricultural productivity and improving farmer’s profitability through judicious and efficient use of chemical fertilizers, organic manures and biofertiliser (Singh *et al*., 2003) [12].

Material Methods
The field experiment was laid out at Faculty of Agriculture Farm, Wadura. There were in all. Twelve (12) treatment combinations. The experiment was laid out in Randomized Complete Block Design (RCBD) and each treatment was replicated four times during *Rabi* season,

2019-20 and 2020-21. The treatments were allocated randomly in each replication, these details are T_1 - RDF N: P_2O_5: K_2O Kg ha^{-1}, T_2 - 80% RDP + 0.6 t Vermicompost ha^{-1}, T_3 - 80% RDP + PSB through seed application, T_4 - 80% RDP + PSB through soil application, T_5 - 80% RDP + 0.3 t V.C ha^{-1} + PSB through seed application, T_6 - 80% RDP + 0.3 t V.C ha^{-1} + PSB through seed application + PSB through soil application, T_7 - 60% RDP + 1.2 t Vermicompost ha^{-1}, T_8- 60% RDP + PSB through seed application, T_9 - 60% RDP + 0.6 t V.C ha^{-1} + PSB through seed application, T_{10} - 3.0 t Vermicompost ha^{-1}, T_{11} - PSB through seed application and T_{12}- PSB through soil application.

The soil of the experimental plot was neutral in reaction and showed low electrical conductivity. While, it was found to be high in organic carbon and K_2O, medium in available N and available Phosphorus.

Total nitrogen content in wheat plant was determined as per the procedure given by Tandon, 1993 [13] while, phosphorus was determined colorimetrically (Chopra and Kanwar, 1978) [4], and total potassium was estimated by flame photometer (Piper, 1966) [9].

Result and Discussion

Effect of integrated phosphorus management on nutrient content in wheat plant

The plant samples were collected periodically and analyzed for various major nutrients *viz*. N, P, K and S. The data was statistically analyzed and interpreted (Panse and Sukhatme, 1967) [8].

Total Nitrogen (N)

The data presented in table 1 revealed that the total nitrogen content in wheat plants at harvest ranged between 1.91 to 2.52 percent. It revealed that the integration of 80 percent P through RDP + 0.3 tan V.C ha^{-1} + PSB through seed + PSB through soil (T_6) recorded maximum nitrogen (2.52%) and minimum (1.91%) when only PSB through soil was applied (T_{12}). From the pooled data, it was also observed that treatment T_6 showed significantly higher total nitrogen over all other treatments. The total N content in plant was increased in all the treatments by combined organic manure, phosphorus, and biofertiliser application which provides a conducive physical environment leading to better root activity, increased root hairs and root elongation of plant and positive effect of phosphorus on cell division and the favorable effect of biofertiliser on plant growth and nutrient content might be attributed to the production of growth promoting hormones *viz*., auxins and gibberellins by phosphate solubilizing microorganisms (Barea *et al*., 1976; Sattar and Gaur, 1987) [1, 10]. A similar result was also observed by Arsalan *et al*., (2016) [17], Yubaraj *et al*., (2016) [18], and Bhavya *et al*., (2018) [5].

Total phosphorus

The total phosphorous content varied from 0.19 to 0.31 percent and it was maximum (0.31%) and minimum (0.19%) in treatment T_6 and T_{12}, respectively. The same trend was also found in pooled data. The increase in phosphorus content in wheat plant may be attributed to the synergistic effect of organic matter and biofertiliser on phosphorus availability due to Solubilization of native phosphate from the soil due to the action of various organic acids liberated during the decomposition of organic matter, which might have increased root growth and resulting in increased phosphorus content. The mechanism believed in increasing the phosphorus content and uptake may be due to reduction of calcium activity in the soil solution via the bonding of Ca^{2+} by the plant root exchange sites and the reduction of Fe^{2+} and Al^{3+} activity in soil solution *viz.* the completing of these cations by root excluded organic ions resulting, in an increased phosphate activity (Drake and Steekel, 1955) [3].

Total Potassium

The total potassium content in a wheat crop at harvest ranged from 2.48 to 2.86 percent. Integration of 100% recommended dose of fertilizer 120:60:30 (N: P_2 O_5: K_2O) kg ha^{-1} (T_1) showed higher potassium, while minimum was in when PSB at treated through soil (T_{12}). A critical look at pool data further indicated that treatment T_1 showed significantly higher total potassium content over the rest of other treatments, while treatment T_2, T_3, T_4, T_5, T_6, T_7, and T_9 was at par with T_1. The total potassium content in plant was also increased in all the treatments overall the treatments during both years and the two-year pooled data on total potassium content in plant compared stage wise and it was revealed that it increased at tillering stage over the flowering stage. These results corroborate the findings of Vandana *et al*., (2008) [14], who revealed that integrated use of RDF with either vermicompost increased the K absorption by wheat. Further, these integrations increase the K content and uptake by grain and straw through maintenance of the continuity of nutrients [Dahiya *et al*., (2008), and Singh *et al*., (2011)] [2, 11].

Table 1: Effect of Integrated Phosphorus Management on Nitrogen (%) Content in Plant at Different Growth Stages of Wheat

Tr. No	Nutrient Content								
	Nitrogen			Phosphorus			Potassium		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	2.38	2.47	2.42	0.27	0.28	0.27	2.85	2.88	2.86
T_2	2.30	2.41	2.35	0.28	0.29	0.28	2.78	2.82	2.80
T_3	2.07	2.12	2.10	0.25	0.26	0.25	2.71	2.73	2.72
T_4	2.00	2.03	2.01	0.24	0.25	0.24	2.70	2.72	2.71
T_5	2.37	2.40	2.38	0.29	0.30	0.30	2.79	2.81	2.80
T_6	2.45	2.60	2.52	0.32	0.33	0.31	2.81	2.84	2.82
T_7	2.22	2.26	2.24	0.24	0.25	0.24	2.74	2.77	2.75
T_8	1.95	1.97	1.96	0.22	0.23	0.22	2.60	2.62	2.61
T_9	2.18	2.20	2.19	0.23	0.24	0.23	2.77	2.79	2.78
T_{10}	2.11	2.15	2.13	0.22	0.23	0.22	2.64	2.66	2.65
T_{11}	1.93	1.94	1.93	0.20	0.21	0.20	2.53	2.56	2.55
T_{12}	1.90	1.92	1.91	0.19	0.20	0.19	2.47	2.49	2.48
Mean	2.15	2.20	2.18	0.24	0.25	0.25	2.70	2.72	2.71

S.E. (m) ±	0.131	0.142	0.106	0.013	0.015	0.010	0.08	0.077	0.064
C. D. (P = 0.05)	0.376	0.408	0.304	0.039	0.044	0.029	0.229	0.223	0.183

Nutrient Uptake

It was observed that different treatments showed significant effect on nutrient uptake by wheat crop during both years *i.e.* 2019-20 and 2020-21.

Table 2: Effect of Integrated Phosphorus Management on Nutrient uptake (kg ha^{-1}) by Wheat plant at Harvest Stage

Tr. No	Nutrient Uptake								
	Nitrogen			Phosphorus			Potassium		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	106.70	120.25	113.47	14.15	16.15	15.15	128.45	143.13	135.79
T_2	104.86	119.10	111.98	15.21	17.51	16.36	129.45	144.06	136.76
T_3	87.50	97.90	92.70	11.68	13.85	12.77	114.85	127.17	121.01
T_4	84.62	94.17	89.40	11.27	13.07	12.17	113.56	125.73	119.64
T_5	109.29	121.74	115.51	16.44	18.91	17.67	134.45	147.50	140.97
T_6	119.02	132.72	125.87	18.07	20.85	19.46	141.27	152.72	147.00
T_7	97.75	109.10	103.43	11.65	13.61	12.63	121.29	135.19	128.24
T_8	80.85	90.53	85.69	9.09	10.87	9.98	108.52	119.46	113.99
T_9	94.36	104.44	99.40	10.53	11.95	11.24	119.47	132.53	126.00
T_{10}	84.79	95.85	90.32	8.39	10.27	9.33	105.76	118.39	112.07
T_{11}	77.54	86.26	81.90	7.73	9.17	8.45	101.74	113.62	107.68
T_{12}	73.45	82.65	78.05	6.93	8.03	7.48	96.56	107.92	102.24
Mean	93.39	104.56	98.98	11.76	13.69	12.72	117.95	130.62	124.28
S.E. (m) ±	6.52	6.234	5.285	0.754	0.595	0.550	5.577	3.961	3.985
C. D. (P=0.05)	18.745	17.937	15.205	2.170	1.713	1.583	16.047	11.396	11.465

Conclusion

It could be concluded that, maximum micronutrient availability in wheat plant, application of 80% RDP + 0.3 t V.C ha^{-1} + PSB through seed application + PSB through soil application produced and sustained good soil health for wheat under rained conditions of temperate Kashmir.

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