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Soil test based fertilizer prescriptions through integrated nutrient management using targeted yield approach for wheat in vertisols of Chhattisgarh

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Abstract

To study the soil test based fertilizer prescription for wheat crop on grain yield, nutrient uptake and soil test data were used for obtaining basic parameters viz., nutrient requirement, contribution of nutrients from soil, fertilizer and organic manure. It was found that wheat crop required 1.93 kg N, 0.52 kg P and 1.94 kg K to produce one quintal grain yield. Fertilizer and soil test efficiencies were estimated 31.49, 20.32 and 64.73 percent and 10.41, 48.08 and 5.48 percent respectively for N P K. The efficiency of FYM in terms of available nutrient was evaluated as 9.34, 4.86 and 4.06 percent respectively. On the basis these parameters, fertilizer N, P₂O₅ and K₂O were derived for different targeted yield of wheat by using FYM as organic component in INM approach.

Keywords: INM, STCR, Wheat, FYM, vertisol

Introduction

India produces wheat in a large quantity with a production of 99.12 million tonnes and productivity of 3350 kg ha⁻¹ in 2018-19, grown in an area of 29.58 million hectares. Wheat is grown in Chhattisgarh in an area of 154.78 thousand hectares with productivity of 988 kg/ha in 2018-19.

Fertilizers are generally applied to crops on the basis of generalized state level fertilizer recommendations. However, the fertilizer requirement of a crop is not a static one and it may vary for the same crop from soil to soil and even from field to field on the same soil. Soil testing as a diagnostic tool, the value of soil testing in both general and specific terms is to identify soil fertility problems and constraints in an area and to give specific fertilizer recommendation based on soil analysis of a farm holding.

Keeping the above facts in view and non-availability of STCR data for wheat crop, the present investigation was contemplated in *vertisol* soils so as to elucidate the significant relationship between soil test values and crop responses to fertilizer and to develop fertilizer prescription equations under IPNS for desired yield target of wheat crop.

Material and Method

A field experiment was conducted at the farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh) on soil test crop response correlation with wheat (variety GW-273) during two rabi consecutive season in 2015-16 and 2016-17 in *Vertisol*. The soil of the experimental field comes under the soil order of *Vertisol*. This soil is locally known as *Kanhar* and identified as Arang II series. It is clayey in texture with 24.3% Sand, 21.4% silt and 54.3% clay, dark brown to black in color, neutral to alkaline in reaction due to presence of lime concretion in lower horizon. The soil is deep to 1-1.5 meter. The structure varied from coarse angular blocky to massive and cloddy and in few cases from prismatic or columnar. Soil is represented as typical *fine montmorillonitic, hyperthermic, udic chromustert*. Some physico-chemical properties of experimental soil were analyzed which found 7.8 pH (1:2.5), 0.19 EC (dSm⁻¹), 36.32 CEC (c mol(p+) kg⁻¹), 5.8 Organic C (g kg⁻¹), 223 Available N (kg ha⁻¹), 18.5 Available P (kg ha⁻¹) and 500 Available K (kg ha⁻¹). The experiment was conducted according to approved layout plan of All India Coordinated Research project for Investigation on Soil

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Test Crop Response Correlation (STCR). A special field technique developed by Ramamurthy *et al.* (1967) [14] was used for this study. The field was divided into three equal long strips and denoted as L₀, L₁ and L₂. Prior to conducting the actual field experiment, a fertility gradient was created by applying the graded doses of N, P and K fertilizer for obtaining the appropriate variation in soil fertility in different strips. Variation in soil fertility with respect to N, P and K were created by applying 100-75-50 and 200-150-100, kg ha⁻¹ of N, P₂O₅ and K₂O in L₁ and L₂ strip, respectively and keeping L₀ strip as unfertilized (control).

The fertilizer materials were used as urea, single super phosphate and muriate of potash for the source of N P and K nutrient, respectively. Full dose of P₂O₅ and K₂O and 1/3rd of N were applied as basal, remaining 2/3rd of N applied in two equal splits as top dressing at tillering and panicle initiation stages. Grain and straw samples were analyzed for N, P and K content (Piper 1966) [13] and total nutrient uptake was computed using grain and straw yield data. Using the data on grain yield, nutrient uptake, pre-sowing soil available nutrients and fertilizer doses applied the basic parameter, *viz.* nutrient requirement (kg q⁻¹), contribution of nutrients from soil and fertilizer sources were calculated as described by Ramamoorthy *et al.* (1967) [14]. The contribution of nutrients from applied FYM was estimated by relating the yield with fertilizer nutrients and FYM. These parameters were used for the formulation of fertilizer adjustment equations for deriving fertilizer doses and the soil test based fertilizer prescription for desired yield target of wheat under N, P, K alone as well as IPNS.

Result and Discussion

Status of available NPK in soil

Before taking the main complex experiment with wheat during *rabi* season 2015-16 and 2016-17, the soil samples from each plot were taken and analyzed for available N, P and K. Table 1 reveals the range and means values of available nutrients (N, P and K) during two wheat seasons. Mean values on soil N ranged from 219-227 and 225-235 kg ha⁻¹ during 2015-16 and 2016-17 *rabi* season, respectively. The level of soil P increased with respect to fertility strips from L₀ to L₂. Average soil P ranged from 13.53-26.33 and 19.08-27.92 kg ha⁻¹ in two wheat seasons. The available K status did not reflect with respect to fertility strips indicating that the soil of experimental field is well supplied with K.

Response of wheat to added nutrients

The results (Table 2) showed the range and average values of wheat yields in relation to fertility strips during two wheat

crop seasons. The ranges of wheat yields were recorded as 5.12-35.91 q ha⁻¹ with average of 25.29 q ha⁻¹ in L₀ strip, 7.85-38.80 q ha⁻¹ with average of 27.88 q ha⁻¹ in L₁ strip and 9.59-42.84 q ha⁻¹ with average of 30.42 q ha⁻¹ in L₂ strip during first wheat season 2015-16. It was also noticed that standard deviation (SD) and per cent coefficient of variation (CV) levels were higher in L₀ strip and they reduced under L₁ and L₂ strips. Similar trends were also observed during next rice season 2016-17. This indicates that variation in soil test values was higher in L₀ strip than those of L₁ and L₂ strips which reflected on crop yields. The increase in wheat grain yields with respect to fertility strips may be due to fertility gradient in soil P status from L₀ to L₂ strip.

Relationship between yield and nutrient uptake

A close association was observed between the yield of wheat and total N, P and K uptake during both the crop seasons (2015-16 and 2016-17). This relation was used to estimate the nutrient requirement for wheat (Table 3). The nutrient requirement (NR) is defined as the amount of nutrient required to produce unit amount of yield. The nutrient requirement can be given by the regression coefficient (b₁) of yield (Y) and total nutrient uptake (U).

$$Y = b_1 U \text{ or } U = 1/b_1 * Y$$

Where, 1/b₁ gives the NR (Nutrient Requirement)

The amount of nutrients absorbed by the crop decides a definite amount of biomass production. The amount of nutrient required to produce one quintal of wheat grain during *rabi* season 2015-16 was found to be 1.94 kg N, 0.53 kg P and 1.94 kg K and 1.93 kg N, 0.52 kg P and 1.95 kg K in the next *rabi* season 2016-17. The overall mean values (Table 4) can be considered as 1.93 kg N, 0.52 kg P and 1.94 kg K to estimate the fertilizer requirement of wheat based on the soil test status to achieve a definite yield target.

Efficiencies of fertilizer, soil test and FYM for Wheat

The efficiencies of fertilizer, soil test and FYM were estimated by using the conventional methods with the help of STCR software developed by ICAR-Indian Institute of Soil Science, Bhopal. Table 5 contained the results for wheat season, 2015-16 and 2016-17. The average values based on two wheat season for fertilizer efficiencies of N, P and K were estimated as 31.49, 20.32 and 64.73 per cent, respectively. Similarly, average soil test efficiencies estimated for N, P and K were as 10.41, 48.08 and 5.48 per cent, respectively. The efficiencies of organic source (FYM) were observed as 9.34% N, 4.86% P and 4.06% K.

Table 1: Range and average values of available N, P and K (kg ha⁻¹) before Wheat (*rabi* seasons, 2015-16 and 2016-17)

Available nutrients	Fertility strips							
	Rabi season 2015-16				Rabi season 2016-17			
	L ₀	L ₁	L ₂	SD	L ₀	L ₁	L ₂	SD
Alkaline KMnO ₄ -N (kg ha ⁻¹)	186-245 (219)	201-245 (225)	201-251 (227)	16.89	178-255 (225)	210-252 (232)	197-261 (235)	18.51
Olsen P (kg ha ⁻¹)	10.32-16.56 (13.53)	13.45-23.92 (18.12)	21.63-35.23 (26.33)	6.21	9.04-32.64 (19.08)	12.25-33.45 (22.09)	20.16-40.89 (27.92)	7.07
Amm. acetate extractable K (kg ha ⁻¹)	443-527 (494)	392-522 (489)	443-537 (499)	28.82	370-536 (496)	384-538 (498)	450-547 (505)	34.55

(Data in parenthesis are mean values)

Table 2: Range and mean of grain yields of Wheat during rabi season 2015-16 and 2016-17 in relation to fertility strips

Fertility Strips	Grain yield (q ha ⁻¹)			SD	CV (%)
	Minimum	Maximum	Average		
Rabi season, 2015-16					
L ₀	5.12	35.91	25.29	9.91	39.18
L ₁	7.85	38.80	27.88	9.81	35.20
L ₂	9.59	42.84	30.42	10.44	34.34
All strips	5.12	42.84	27.86	10.14	36.39
Rabi season, 2016-17					
L ₀	8.24	40.81	28.98	10.97	37.88
L ₁	9.13	43.67	31.93	10.68	33.46
L ₂	12.07	49.87	34.43	11.68	33.92
All strips	8.24	49.87	31.78	11.19	35.21

Table 3: Relation of Wheat yield (Y) with total nutrient uptake (U)

Nutrient	2015-16		2016-17	
	Y = b ₁ U	R ²	Y = b ₁ U	R ²
N	Y = 1.91 U	0.98	Y = 1.89 U	0.98
P	Y = 0.48 U	0.79	Y = 0.48 U	0.77
K	Y = 1.86 U	0.89	Y = 1.87 U	0.88

Table 4: Nutrient requirements for Wheat (var. GW-273)

Nutrient	Nutrient requirement for one quintal grain yield of Wheat (kg q ⁻¹)		
	2015-16	2016-17	Mean
N	1.94	1.93	1.93
P	0.53	0.52	0.52
K	1.94	1.95	1.94

Table 5: Efficiencies of fertilizer, soil and FYM for Wheat

Nutrient	Nitrogen			Phosphorus			Potassium		
	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean
Fertilizer efficiency (%)	29.49	33.49	31.49	20.44	20.21	20.32	61.57	67.9	64.73
Soil Test efficiency (%)	9.96	10.86	10.41	45.50	50.66	48.08	4.87	6.09	5.48
FYM efficiency (%)	10.26	8.41	9.34	5.50	4.22	4.86	4.39	3.73	4.06

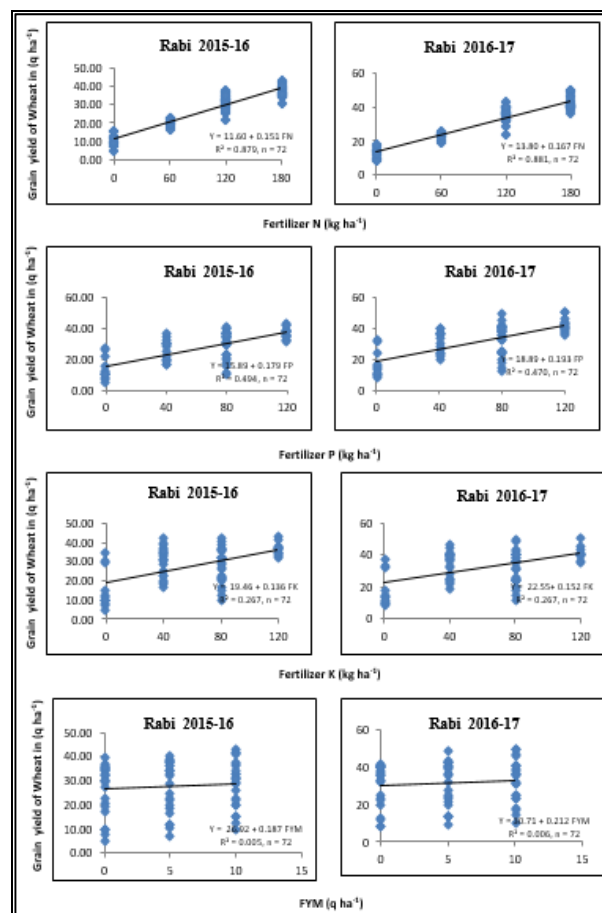
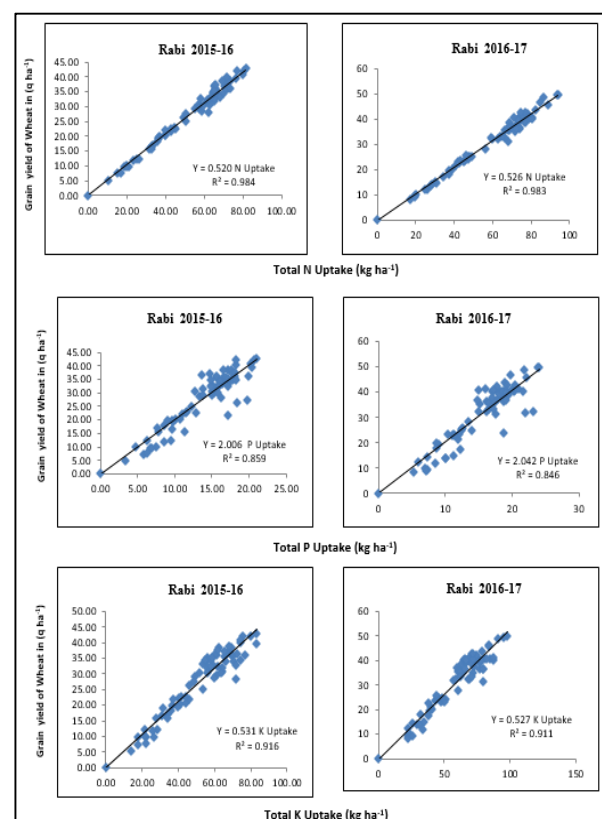
Table 6: Fertilizer adjustment equations for Wheat (GW-273)

S. No.	Fertilizer adjustment equations for Wheat
1	FN = 6.12 Y - 0.33 SN - 0.29 FYM
2	FP = 2.55 Y - 2.36 SP - 0.23 FYM
3	FK = 2.99 Y - 0.08 SK - 0.06 FYM

Where, FN, FP and FK are fertilizer N, P₂O₅ and K₂O (Kg ha⁻¹) respectively. FYM is Farm Yard Manure (t ha⁻¹). SN, SP and SK are soil test values (kg ha⁻¹) for KMnO₄- N; Olsen's P and ammonium acetate extractable K and Y is crop yield in q ha⁻¹

Estimation of Fertilizer adjustment equation

Fertilizer adjustment equations were evolved for Wheat crop to achieve a definite yield target based on the basic parameters viz. nutrient requirement, efficiencies of fertilizer, soil test and organic source (FYM). The following equations given in Table 6 were evolved for Wheat for fertilizer N, P₂O₅ and K₂O. Many fertilizer adjustment equations have been developed by STCR. Such kind of fertilizer prescription equation for different crops (rice, wheat, maize, mustard and rapeseed) have been documented by Milap-Chand *et al.* (2006) [8], Sharma and Singh (2005), Keram *et al.*, (2012) [9], Gupta *et al.* (2006) [8], Mahajan *et al.* (2013) [10].

**Fig 1:** Response of Wheat to different levels of FYM application and fertilizer N, P₂O₅ and K₂O in rabi season 2015-16 & 2016-17**Fig 2:** Relationship between Wheat grain yield and Total NPK Uptake, Rabi season 2015-16 and 2016-17

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