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Soil test crop response based fertilizer prescriptions under integrated plant nutrient supply for targeted yield of potato (*Solanum tuberosum* L) in Inceptisols

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Abstract
Field experiment were carried out on potato (*Solanum tuberosum L*) during rabi 2018-19 to investigate the soil test crop response based fertilizer prescriptions under integrated plant nutrient supply by following Ramamoorthy's inductive approach of fertility gradients in Inceptisols at the Instructional Farm of Krishi Vigyan Kendra, Raigarh (C.G.). The fertilizer adjustment equations were derived by the All India Coordinated Research Project (AICRP), College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The nutrient requirement (NR), contribution of nutrients from soil (CS), fertilizer (CF) and farm yard manure (CFYM) were computed using the data on soil test values, fertilizer nutrients doses, nutrient uptake and potato yield. The amount of nutrient required (NR) to produce one quintal of tuber production was found to be 0.42 kg N, 0.11 kg P and 0.45 kg K. The per cent contribution from fertilizer (CF) for N, P and K was estimated 31.27,22.06 and 82.93 per cent for potato crop. The per cent contribution from soil (CS) was recorded as 14.39 for N, 48.94 for P and 17.78 for K in case of potato crop. The per cent contribution of organic source (CFYM) for N, P and K were recorded 8.33, 3.50 and 19.60 for potato crop. Based on this information, soil test based fertilizer prescription equations were developed to predict fertilizer recommendation for obtaining specific yield target of potato crop. Ready reckoners chart for fertilizer N, P_2O_5 and K_2O application based on the soil test values for specific yield targets of potato were also prepared which are useful for the soil testing laboratories.

Keywords: Potato, STCR, FYM, fertilizer recommendations, ready reckoner

Introduction
Efficient fertilizer use ensures increased production, high profit and environmental friendly. The most appropriate balanced and economic doses of fertilizers can be evolved on the basis of soil test and crop response studies. At present, about 10 million tonnes gap between nutrients removal by the crops and nutrients addition through various sources has been estimated in the country. The organic resources available (organic manure, crop residues and bio-fertilizers) presently could meet this gap but at present only one third of these resources are used in agricultural production. Fertilizers are generally applied to crops on the basis of generalized state level fertilizer recommendations which lead imbalance use of fertilizers and economic loss because the fertilizer requirement of a crop is not a static one and it may vary from field to field for same crop on the same soil. Therefore, it is essential to protect the soil health by adopting balanced fertilization through soil testing and organic source as an integrated nutrient management (INM) approach (Singh 2017 and Singh and Singh 2018) [11, 13]. Considering the soil fertility status, crop requirement of nutrients, efficiency of fertilizer, soil and organic source and the economic condition of the cultivator, it has now been possible to formulate a yield target oriented fertilizer schedule based on the principle of balanced nutrition of crops. In India, Ramamoorthy *et al.* (1967) [5] established the theoretical basis and experimental proof for the fact that Liebig's law of minimum operates equally well for N, P and K. Among the various methods of fertilizer recommendation, yield targeting is unique in the sense that this method not only indicate soil test based fertilizer dose but also the level of yield that farmer can hope to achieve if good agronomic practices are followed in raising the crop. One of the most important advantages of this approach is that farmers have the option to relate their resources with a desired level of yield target. One of the reasons for lower production is imbalanced use of fertilizers by the farmers without knowing soil fertility status and nutrient requirement of crops causes adverse effects on soil and crop both in terms of nutrient toxicity and deficiency (Ray *et al.,* 2000) [6]. Micro situation level specific fertilizer recommendations are possible for soils of varying fertility resource conditions of farmers

and levels of targeted yield and for similar soil classes and environment (Ahmed *et al.*, 2002) [1]. Targeted yield concept thus, strikes a balance between fertilizing the crop and soil. In the light of ever increasing prices coupled with increasing demand of chemical fertilizer and depleting soil fertilizer necessitates the integrated use of organic (renewable) and inorganic (non-renewable) sources of nutrient for sustainable crop production and better soil health. Therefore, there is a need for improvement of input use efficiency through proper integration of chemical fertilizer with organic manure by balanced nutrition of crop. Potato (*Solanum tuberosum L.*) crop are the most important tuber crop of the world that supplement the carbohydrate requirement of population. Maize-potato cropping system is followed in Chhattisgarh including Raigarh district. Information on soil test based balanced fertilizer doses for this cropping system is not available for Raigarh district that calls to generate through complex fertilizer experiment using soil test crop response concept on targeted yield approach. Keeping these aspects in view, the present study was undertaken to develop a basis balanced fertilizer recommendation based on soil test values for desired yield targets of potato in Inceptisols of Chhattisgarh.

Materials and Methods

Field experiment were carried out on potato (*Solanum tuberosum L*) during rabi 2018-19 to investigate the soil test crop response based fertilizer prescriptions under integrated plant nutrient supply by following Ramamoorthy's inductive approach of fertility gradients in Inceptisols at the Instructional Farm of Krishi Vigyan Kendra, Raigarh (C.G.). The experimental site is located on the Northern part of Chhattisgarh and lies at 21°54'N latitude and 83°24' E longitude with an altitude of 215 m above the mean sea level (MSL). The experimental field was an Inceptisols of silty clay loam texture with pH 6.50, electrical conductivity (EC) 0.13 dSm,$^{-1}$ organic carbon (OC) 5.3 g kg,$^{-1}$ cation exchange capacity (CEC) 18.6 cmol (p+) kg^{-1}, available N 235 kg ha^{-1}, available P 14.2 kg ha^{-1}, available K 337 kg ha^{-1}, available S 22.3 kg ha^{-1}, available Ca 1848 kg ha^{-1}, available Mg 856 kg ha^{-1}, available Fe 28.35 mg kg^{-1}, available Mn 19.52 mg kg^{-1}, available Cu 2.01 mg kg^{-1}, available Zn 1.41 mg kg^{-1} and available B 0.53 mg kg^{-1}. The experiment was conducted in the inductive approach in which fertility ingredients were created by dividing the field into three strips of equal size. No fertilizers were applied in first strip. Second strip was treated with 120, 60 and 60 kg ha^{-1} of N, P_2O_5 and K_2O, respectively and third strip was treated with 180, 90 and 90 kg ha^{-1} of N, P_2O_5 and K_2O, respectively. Green gram was grown for natural transformation of applied fertilizer and grown crop was burried before main experiment and soil of each fertility strip was tested to confirm the creation of fertility ingradients with respect to N, P and K. The purpose of creating the fertility ingradients was to obtain variable soil test values in the same field and eliminate the influence of climate and management practices on crop yield instead of conducting experiment in field with variable nutrients. After confirming the establishment of fertility ingradients in the experimental field, the experiment was laid out for sowing the test crop of potato 10th November, 2018. For soil test crop response studies, each strip was sub-divided into 24 plots of 8.0 x 4 m^2 each. The initial surface (0-15 cm) soil samples were collected from each of the 72 plots and analyzed for available N (Subbiah and Asija, 1956) [18], available P (Olsen *et al*, 1954) [4] and available K by neutral normal ammonium acetate (Jackson 1973) [3].

Twenty four selected fertilizer treatment combinations (Table 1) were applied in maize comprising 4 levels of N (0, 60, 120, 180 kg h^{-1}), P_2O_5 (0, 30, 60, 90 kg h^{-1}) and K_2O (0, 30, 60 90 kg h^{-1}) and same doses in the same treatment structure was taken with potato crop during *Rabi* 2018-19. Three levels of FYM *i.e.* 0, 5 and 10 t ha^{-1} was also applied across the width of strip making three blocks of FYM. The different treatments were randomized in such a way that each FYM block fertility strip had the same 24 treatment combinations. Each strip comprised of one absolute control, two FYM levels, seven treatments of selected combinations of fertilizer nutrients alone and fourteen treatments in which both fertilizer and FYM were applied jointly. The test crop (potato) was raised up to maturity by following standard agronomic practices in same field. The N, P and K were applied through urea, single superphosphate (SSP) and muriate of potash (MOP), respectively. Full dose of fertilizer P and K and half of N was applied as basal and remaining dose of N was applied in two splits before flowering. Tuber yield of the crop was recorded and plant samples were analyzed for N, P and K contents to work out their uptake. The data on tuber yield, uptake of N, P and K, available N, P and K and fertilizer and FYM nutrient doses for N, P_2O_5 and K_2O were used to compute the basic parameters viz, nutrient requirement (NR) contribution of nutrients from soil (CS), contribution of nutrients from fertilizers (CF) and contribution of nutrients from FYM (CFYM) were computed following the equations given by Ramamoorthy *et al* (1967) [5]. These basic data was transformed into simple workable fertilizer adjustment equations for calculating N, P and K fertilizers doses for yield targets based on initial soil test values under integrated plant nutrient supply (IPNS).

Table 1: Nutrient combinations of Fertilizer and FYM treatments in different strips

Plot No.	Strip I	Strip II	Strip III
1	$N_2P_3K_3F_2$	$N_0P_0K_0F_2$	$N_2P_2K_0F_2$
2	$N_3P_3K_3F_2$	$N_1P_2K_1F_2$	$N_3P_2K_2F_2$
3	$N_0P_0K_0F_1$	$N_1P_1K_2F_1$	$N_0P_0K_0F_1$
4	$N_2P_3K_2F_1$	$N_0P_0K_0F_1$	$N_1P_2K_1F_1$
5	$N_2P_2K_3F_0$	$N_3P_1K_1F_0$	$N_1P_1K_2F_0$
6	$N_2P_2K_2F_0$	$N_2P_1K_2F_0$	$N_0P_2K_2F_0$
7	$N_0P_0K_0F_2$	$N_1P_1K_1F_2$	$N_2P_2K_2F_2$
8	$N_OP_2K_2F_2$	$N_2P_2K_1F_2$	$N_2P_1K_2F_2$
9	$N_3P_1K_1F_1$	$N_3P_3K_1F_1$	$N_2P_1K_1F_1$
10	$N_3P_2K_2F_1$	$N_3P_2K_3F_1$	$N_1P_1K_1F_1$
11	$N_3P_2K_1F_0$	$N_3P_2K_2F_0$	$N_3P_3K_2F_0$
12	$N_0P_0K_0F_0$	$N_0P_0K_0F_0$	$N_3P_2K_3F_0$
13	$N_3P_3K_1F_2$	$N_2P_1K_1F_2$	$N_3P_1K_1F_2$
14	$N_3P_3K_2F_2$	$N_2P_2K_3F_2$	$N_1P_2K_2F_2$
15	$N_2P_1K_2F_1$	$N_3P_3K_2F_1$	$N_2P_2K_1F_1$
16	$N_1P_2K_2F_1$	$N_3P_3K_3F_1$	$N_2P_0K_2F_1$
17	$N_1P_2K_1F_0$	$N_2P_2K_2F_0$	$N_3P_3K_1F^0$
18	$N_1P_1K_1F_0$	$N_1P_2K_2F_0$	$N_3P_3K_3F_0$
19	$N_1P_1K_2F_2$	$N_2P_0K_2F_2$	$N_0P_0K_0F_2$
20	$N_3P_2K_3F_2$	$N_3P_2K_1F_2$	$N_2P_3K_2F_2$
21	$N_2P_2K_0F_1$	$N_0P_2K_2F_1$	$N_3P_2K_1F_1$
22	$N_2P_2K_2F_1$	$N_2P_3K_3F_1$	$N_2P_2K_3F_1$
23	$N_2P_1K_1F_0$	$N_2P_3K_2F_0$	$N_0P_0K_0F_0$
24	$N_2P_2K_1F_0$	$N_2P_2K_0F_0$	$N_2P_3K_3F_0$

Where N_0, N_1, N_2 and N_3 are 0,60,120 and 180 kg N ha^{-1}, P_0, P_1, P_2 and P_3 are 0,30,60 and 90 kg P_2O_5 ha^{-1}, K_0, K_1, K_2 and K_3 are 0,30,60 and 90 kg K_2O ha^{-1} and F_0, F_1 and F_2 are 0, 5 and 10 t FYM ha^{-1}, respectively

Results and Discussion

Soil available nutrients

The experimental soils range and mean values of available N, P and K after creation of fertility ingradients and before sowing (initial) of potato crop in different strips indicated that soil test values for these nutrients varied widely both among as well as with in different strips (Table 2). The available nitrogen varied from 188 to 226 kg ha^{-1}, available phosphrus varied from 11.18 to 45.06 kg ha^{-1} and available potassium from 123 to 349 kg ha^{-1} of initial soils of potato crop. Though these soils are considered to be most fertile, they are deficient in nitrogen and organic content but moderately supplied with phosphorus and potassium. Such variation in nutrient status of experimental site is ideal for conducting soil test crop response experiment.

Table 2: Initial soil test values of potato field

Strip	Available N (kg ha^{-1})		Available P (kg ha^{-1})		Available K (kg ha^{-1})	
	Range	Mean	Range	Mean	Range	Mean
I	188-231	210	11.18-22.98	17.08	133-289	211
II	191-226	209	21.71-43.59	32.65	123-324	224
III	198-231	214	30.50-45.06	37.78	166-349	257
SD		10.19		10.59		50.43
CV (%)		4.81		37.53		22.45

Tuber yield

The grain yield of potato in control plots ranged from 50.45 to 204.06 q ha^{-1} in different fertility strips (Table 3). Variation in control yield of potato between strips might be due to variation in soil fertility status. Maize yield increased from 20.86 q ha^{-1} in control to 84.14 q ha.$^{-1}$ Potato yield increased from 50.45 q ha^{-1} in control to 204.06 q ha^{-1}, where 180, 90 and 90 kg ha^{-1} N, P_2O_5, K_2O and 10 t FYM ha^{-1} in highly fertilized plots, respectively. This reveals that there was a tremendous response to applied nutrients in potato. The yield in various treatments were in accordance with the doses nutrient and FYM, indicating high responsiveness of the crop to soil fertility and fertilizer application. The average tuber yield of potato in strip I, II and III were 122.60, 135.45 and 138.41 q ha^{-1}, respectively. The yields and soil test values (Table 2 and 3) clearly depicted their wide variation in control and treated plots. Such type of variation in data is prerequisite for computation of fertilizer adjustment equations for targeted yield of the crop (Sharma and Singhal 2014, Singh *et al.* 2017 and Singh *et al.* 2018) [9, 12, 14].

Table 3: Potato tuber yield

Fertility strip	Potato tuber yield (q ha^{-1})			SD	CV (%)
	Minimum	Maximum	Average		
I	50.45	194.75	122.60	45.66	31.53
II	69.64	201.26	135.45	42.30	27.97
III	72.76	204.06	138.41	42.30	27.32
Average	64.29	200.02	132.15	43.04	28.63

Targeted yield equations and ready reckoners

The amount of nitrogen, phosphrus and potassium (NR) required for production of one quintal of tuber yields of potato was found to be 0.42, 0.11 and 0.45 kg q^{-1}, respectively (Table 4). Thus, it is possible to calculate the N, P_2O_5 and K_2O requirements of the crop for desired specific yield target (Suri and Verma, 2002, Bajendra *et al.* 2012 and Singh *et al.* 2019) [19, 2, 17]. The per cent contribution nutrients from fertilizer (CF) were estimated 31.27, 22.06 and 82.93 per cent for potato, respectively. The per cent contribution from soil (CS) to total nutrient removal for N, P_2O_5 and K_2O were recorded 14.39, 48.94 and 17.78 for potato, respectively. Ramamoorthy *et al.* (1967) [5] and Santhi *et al.* (2004) [8] also reported efficiency and contribution of soil and fertilizer for tuber yield of potato in Inceptisols. However, the per cent contribution from organic source (CFYM) were recorded 8.33, 3.50 and 19.60 for potato, respectively, which was much lower than contribution from fertilizers and soil. These results indicated that there was remarkable contribution of soil nutrients. Similar results have been reported by Singh *et al.* (2014) [10], Sahu *et al.* (2017) [7] and Singh *et al.* (2019) [17] for wheat crop. The soil test based fertilizer N, P_2O_5 and K_2O adjustment equations for target yield of rice and wheat were developed by using the basic data (Table 4). Fertilizer adjustment equation with regard to nitrogen, phosphorus and potassium requirement for targated yield of mize and potato were FN = 1.35 Y - 0.46 SN - 0.27 FYM, FP = 0.48 Y- 2.22 SP - 0.16 FYM and FK = 0.54 Y- 0.21 SK- 0.24 FYM, respectivly.

The developed eqations were useful in creating fertilizer prescriptions for potato crops in Inceptisols of Raigarh, Chhattisgarh, having similar soil and agro-climatic conditions. The equations are dynamic in nature as the doses of nutrients vary with the target yield of potato. The doses of fertilizer nutrients decreased with each unit increase in soil test values and vice-versa. These equation can be used for fertilizers alone or with FYM in mize- potato croping systems of Chhattisgarh. The STCR based fertilizer application would serve the purpose of balance nutrient supply to the crops and improved efficiencies of inputs. The ready reckoner of soil based fertilizer prescriptions for various soil test values of N, P and K for getting different yield targets. (Table 5). Fertilizer rates increased as yield target of potato and fertilizer doses decreased as soil test values. Thus, in targeted yield concept, yield potential of the crop variety and soil test values were taken into consideration while making fertilizer prescriptions.

From these results, it may be concluded that the soil test based fertilizer N, P_2O_5 and K_2O adjustment equations for target yield of potato under integrated plant nutrient supply (IPNS) would result in balanced fertilization to achieve a pre-decided yield targets. The STCR based fertilizer prescriptions may be popularized for higher production of potato as well as higher efficiency use of nutrients so as to improvement of farmer's economy. The fertilizers may be calculated for lower/higher yields targets depending upon the availability of inputs. The ready reckoner may be used by soil testing laboratories for fertilizer recommendations in Chhattisgarh state.

Table 4: Soil test based fertilizer adjustment equations for targeted tuber yield of potato

Parameters	Potato		
	N	P_2O_5	K_2O
NR (kg q^{-1})	0.42	0.11	0.45
CF (%)	31.27	22.06	82.93
CS (%)	14.39	48.94	17.78
CFYM (%)	8.33	3.50	19.60
Fertilizer adjustment equations	FN = 1.35 Y - 0.46 SN - 0.27 FYM FP = 0.48 Y- 2.22 SP - 0.16 FYM FK = 0.54 Y- 0.21 SK- 0.24 FYM		

Table 5: Ready reckoner of soil test based fertilizer recommendations for potato (Kufri Jyoti) in Inceptisols with 5 tons of FYM

Soil Test values (kg ha^{-1})			Yield Target of potato (q ha^{-1})								
			100			150			200		
N	P	K	FN	FP	FK	FN	FP	FK	FN	FP	FK
150	4	200	65	39	11	166	63	38	200	87	65
175	6	225	53	34	6	154	58	33	188	82	60
200	8	250	42	30	6	143	54	28	177	78	55
225	10	275	30	25	6	131	49	23	165	73	50
250	12	300	19	21	6	120	45	17	154	69	44
275	14	325	7	16	6	108	40	12	142	64	39
300	16	350	7	12	6	97	36	7	131	60	34
325	18	375	7	8	6	85	32	7	119	56	29
350	20	400	7	3	6	74	27	7	108	51	23
375	22	450	7	3	6	62	23	7	96	47	13
400	24	500	7	3	6	51	18	7	85	42	2

References

1. Ahmed S, Raizuddin M, Krishna Reddy PV. Optimizing fertilizer doses for rice in alluvial soils through chemical fertilizers, farm yard manure and green manure using soil test values. Agropedology. 2002; 12:133-40.
2. Bajendra, Patiram, Singh LS. Soil test based fertilizer recommendation and verification for maize grown in mid hills of Meghalaya. An Asian Journal of Soil Science. 2012; **7**(1):124-26.
3. Jackson ML. Soil Chemical Analysis. Prentice-Hall of India Pvt Ltd., New Delhi, 1973.
4. Olsen SR, Cole CV, Watnable FS, Dean LA. Estimation of available phosphorous in soils by extraction with sodium carbonate. U.S.D.A., Circular No. 1954; 933:1-10.
5. Ramamoorthy B, Narasimhan RL, Dinesh RS. Fertilizer application for specific yield targets of Sonara-64. Indian Farming. 1967; 17(5):43-45.
6. Ray PK, Jana AK, Maitra DN, Saha MN, Chaudhury J, Saha S *et al*. Fertilizer prescriptions on soil test basis for jute, rice and wheat in a *Typic ustochrept*. Journal of Indian Society of Soil Science. 2000; 48:79-84.
7. Sahu V, Srivastava LK, Mishra VN, Banwasi R, Jatav GK. Development of fertilizer prescription equation for SRI-rice – wheat cropping system under integrated plant nutrient system in *Vertisol*s of Chhattisgarh plains. Annals of Plant and Soil Research. 2017; 19(4):413-17.
8. Santhi R, Natesan R, Andi K, Selvakurnan J. Soil test based fertilizer recommendation for sunflower. *(Heliathus annus* L). in *Inceptisol* of Tamil Nadu. Journal of Oil Seed Research. 2004; 21(1):78-81.
9. Sharma VK, Singhal SK. Validation of soil test based fertilizer prescriptions for targeted yield of pearl millet, rice, wheat and mustard on Inceptisols at farmer’s field. Annals of Plant and Soil Research. 2014; 16(4):367-71.
10. Singh YV, Singh SK, Sharma PK, Singh, Priyanka. Soil test crop response based fertilizer recommendation for wheat in an Inceptisols of eastern plain zone of Uttar Pradesh. Journal of the Indian Society of Soil Science. 2014; 62:255-58.
11. Singh V. Effect of balanced use of nutrients on productivity and economics of wheat (*Triticum aestivum*). Annals of Plant and Soil Research. 2017; 19(1):105-109.
12. Singh, Mohinder, Goyal V, Panwar BS, Sangwan PS. Soil test crop response based fertilizer recommendation under integrated plant nutrient supply for *Bt* cotton in Inceptisols of Haryana. Journal of the Indian Society of Soil Science. 2017; 65:80-85.
13. Singh S, Singh V. Maximizing of wheat (*Triticum aestivum*) productivity and profitability using site specific nutrient management strategy. Annals of Plant and Soil Research. 2018; 20(1):103-106.
14. Singh SP, Patel, Pushpendra Kumar, Patel, Chanchala Rani, Paikra KK *et al*. Soil test crop response based fertilizer recommendation under integrated plant nutrient supply for rice-wheat cropping system in Inceptisols of Raigarh, Chhattisgarh. Annals of Plant and Soil Research. 2018; 20(2):153-58.
15. Singh SP, Paikra KK, Patel, Chanchala Rani. Performance of soil test crop response on productivity and profitability of Rice (*Oryza sativa*) in Inceptisols of Raigarh District of Chhattisgarh plains. Annals of Agricultural Research. 2018; 39(2):147-52.
16. Singh SP, Paikra KK, Patel, Chanchala Rani. Soil Test Crop Response: An effective approach for integrated plant nutrient supply for maize- potato cropping system in Inceptisols of Raigarh District of Chhattisgarh plains. International Journal of Agriculture Sciences. 2018; 10(9):5958-61.
17. Singh SP, Patel, Chanchala Rani, Paikra KK. Response of integrated plant nutrient supply under soil test crop response based fertilizer recommendation on targeted yield and economics of wheat (*Triticum aestivum*) in Inceptisols of Chhattisgarh plains. International Journal of Agriculture Sciences. 2019; 11(17):9007-10.

18. Subbiah BV, Asija GL. A rapid procedure for estimation of available nitrogen in soils. Current Science. 1956; 25:259-260.
19. Suri VK, Verma TS. Nutrient efficiency and their evaluation maize (Cv. Parvati) and wheat (cv. Aradhana) on farmers' field for prescription based fertilizer recommendations, Research on Crops. 2000; 1(2):128-32.