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Soil test based fertilizer prescription model under integrated plant nutrient management system for pea on alluvial soil

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Abstract
Studies on Soil test Crop Response based Integrated Plant Nutrient Management System (STCR-IPNMS) were conducted for the desired yield targets of Pea, on alluvial soil of Agricultural Research Farm, Banaras Hindu University, Varanasi during *rabi* 2017. Testing of developed fertilizer prescription equation is necessary to demonstrate the effectiveness of technology delivery to the stake holders in need. To assess the validation of fertilizer prescription a series of experiment was setup in four locations of eastern plain zone of Utter Pradesh. Soils of the selected location are analyzed initially for available N, P and K. Treatments include control, farmer practices, general recommended dose of fertilizer and STCR based fertilizer dose for an yield target of 15 and 20 q ha^{-1} and STCR based fertilizer dose for an yield target of 17 and 22 q ha^{-1} with 2 t ha^{-1} FYM. The treatments were imposed and cultivation practices were carried out periodically and the grain yield was recorded at harvest. Using the data on grain yield and fertilizer doses applied, per cent increment in yield and benefit cost ratio (B:C) were worked out. The results of the experiments indicated that in all the four locations, the per cent achievement of the targeted yield was within±10% variation proving the validity of the equations for prescribing integrated fertilizer doses for pea. The highest per cent increment in yield was recorded in the yield target of 22 q ha^{-1} (49.13 per cent) followed by 17 q ha^{-1} (34.00 per cent) over farmer's practice. The highest mean grain yield was recorded in STCR-IPNMS–22 q ha^{-1} (2175 kg ha^{-1}). The highest benefit: cost ratio (7.92) was recorded in STCR-IPNMS 22 q ha^{-1} is followed by STCR-IPNMS 17 q ha^{-1} (6.78). The fertilizer prescription equations developed for pea under IPNMS can be recommended for alluvial Inceptisol of eastern Utter Pradesh for achieving a yield target of 22 q ha^{-1} with higher economic return.

Keywords: Fertilizer prescription, STCR-IPNMS, Pea, B:C Ratio, yield target etc.

Introduction
As per increase in the population exponentially, the demand of food grain and other means have found most serious issues for human survival and their development. During the green revolution era, it is well known that the production of pulses were not in attention through which a massive decrease in their production happened. But now day's agriculture scientists felt these problems and doing their job in producing more pulses as much as possible efficiently with scientific manner. Keeping all these in mind, Food and Agriculture Organization (FAO) of the United Nations declared year '2016' as an 'International Year of Pulses'. "Pea" is also a major pulse crop which is growing in India as well as in the world. Field pea (*Pisum sativum* L.) is a leguminoceae family crop and is a native of central or Southeast Asia (Warren *et al.*, 1956). It is also known as 'Dry Pea' and commonly known as 'Matar' in India. Field pea is one of the widespread pulse crop in the world as like in India. Pea is the third most important pulse crop at global level, after dry bean and chickpea and third most popular rabi pulse of India after chickpea and lentil. In India, field pea is grown over an area of 11.50 lakh ha with a production of about 10.36 lakh tonnes during XII Plan period (2012-15). Uttar Pradesh is the major field pea growing state with 459000 tonnes of production in 307000 ha areas (2012-13). It alone produces about 49 % of pea produced in India. Besides Uttar Pradesh, Madhya Pradesh, Bihar and Maharashtra are the major pea producing states (Anonymous, 2015) [1]. 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) [10]. It can be corrected only with proper organic manure and inorganic fertilizer schedule based on soil fertility evaluation. Soil test based fertilizer prescription eliminates over or under usage of fertilizer inputs thereby increasing the fertilizer use efficiency and yield of crops. Soil testing becomes one of the vital tools in increasing the yield of crops by optimum prescription of fertilizers to crops and maintenance of soil fertility.

Truog (1960) [15] outlined the relationship between soil available nutrients and yield. Ramamoorthy *et al.* (1967) [8] established the fact that there existed a linear relationship between the nutrient absorbed by the plant and the grain yield or economic produce. A unique field experimental approach (Inductive methodology) on soil test crop response correlation studies was evolved through creating a macrocosm of soil fertility variability within a microcosm of an experimental field Ramamoorthy *et al*. (1967) [8] by applying graded doses of fertilizers. This provides a scientific basis for balanced fertilization not only between fertilizer nutrients but also with the soil available nutrients. Keeping the above facts in view a study was carried out for pea in alluvial soil (Inceptisol), eastern plain zone of Uttar Pradesh at farmer field to validate the fertilizer prescription equation develop by STCR- IPNMS model.

Materials and Methods

To assess the validation of fertilizer prescription equation for Pea developed by STCR-IPNMS model, field experiment were carried out in different locations of four farmers of alluvial soil of eastern plain zone of Utter Pradesh. Experiments were set up at one location Persiya village in Naugarh block of Chandauli district, Utter Pradesh. Initial soil samples were collected from each location and analyzed for pH was determined in1:2.5 soil-water suspension by potentiometer method (Jackson1973) [3]. Electrical conductivity was determined extract using Conductivity Bridge and expressed as dSm^{-1} (Jackson 1973) [3], organic carbon (Walkely and Black, 1934) [16], alkaline $KMnO_4$-N (Subbiah and Asija, 1956) [13], Olsen-P (Olsen *et al*., 1954) [5], NH_4OAc-K (Hanway and Heidal, 1952) [2]. The initial soil fertility status for different locations is shown in Table 1. Fertilizer prescription equations developed for pea under STCR- IPNMS on eastern plain zone of utter Pradesh, are given below:

Nitrogen dose (kg ha^{-1})) =4.15*T-.27SN-.09*FYM-N
Phosphorus dose (kg ha^{-1}) = 3.18*T- 2.08* SP-0.12* FYM-P
Potassium dose (kg ha^{-1}) = 4.31*T-0.32*K-0.14*FYM-K

Where, FN, FP_2O_5 and FK_2O are fertilizers N, P_2O_5 and K_2O in kg ha^{-1}, respectively; T=Grain yield target in q ha^{-1}; SN, SP and SK are available N, P and K through soil in kg ha^{-1}, respectively; ON, OP and OK are N, P and K supplied through FYM in kg ha^{-1}. The treatments imposed were as follows : (i) Control, (ii) Farmer's Practices, (iii) General Recommended Dose, (iv) STCR based fertilizer dose for an yield target of 15 q ha^{-1} (v) STCR based fertilizer dose for an yield target of 20 q ha^{-1} (vi) STCR-IPNMS based fertilizer dose for an yield target of 17 q ha^{-1} (vii) STCR-IPNMS based fertilizer dose for an yield target of 22 q ha^{-1}. Based on the initial soil test values of available N, P and K and the quantities of N, P_2O_5 and K_2O supplied through FYM, fertilizer doses were calculated and applied for STCR treatments for various yield targets.

Table 1: Initial soil fertility status of the different locations of Villege-Persiya, Naugarh block

Locations	Farmers Name	pH	E.C. (dSm^{-1})	OC (%)	Avai. N (kg ha^{-1})	Avai. P (kg ha^{-1})	Avai. K (kg ha^{-1})
1.	Smt. Phuieshari w/o. Sri Bhagvandas	7.4	0.37	0.68	180.00	25.00	180.00
2.	Smt. Shankuntla devi w/o. Sri Devnarayan	7.4	0.36	0.67	182.00	26.70	183.00
3.	Sri. Ramlakhan f/o. Sri Zhamaran	7.5	0.36	0.68	185.00	27.00	187.00
4.	Smt. Lalti w/o Sri Jayshankar	7.5	0.39	0.72	187.00	28.80	186.00

Treatments (VI) and (VII) received FYM @ 2 t ha^{-1} and NPK fertilizers were applied after adjusting the nutrients supplied through FYM based on STCR-IPNMS equations (Table 2). Fifty per cent of N and full dose of P_2O_5 and K_2O were applied basally and the remaining 50% N was applied on 30 days after sowing and all other packages of practices were carried out periodically. Using the data on grain yield and fertilizer doses applied, the parameters viz., B: C ratio was worked out based on the price of the produce and cost incurred for the cultivation as per the standard procedure.

Table 2: Treatments of fertilizer doses (kg ha^{-1}) imposed under different locations.

Treatments	Location 1			Location 2			Location 3			Location 4		
	N	P	K	N	P	K	N	P	K	N	P	K
Control	0	0	0	0	0	0	0	0	0	0	0	0
Farmer's practice	10	20	15	10	20	15	10	20	15	10	20	15
GRD	20	40	30	20	40	30	20	40	30	20	40	30
STCR-IPNMS* 15 q ha^{-1}	19	27	20	19	27	20	19	27	20	19	27	20
STCR-IPNMS* 20 q ha^{-1}	40	43	41	40	43	41	40	43	41	40	43	41
STCR-IPNMS* 17 q ha^{-1}	27	32	26	27	32	26	27	32	26	27	32	26
STCR-IPNMS* 22 q ha^{-1}	46	48	48	46	48	48	46	48	48	46	48	48

Where: GRD – General recommended dose, *FYM @2 t ha^{-1}

Results and Discussions

The highest mean grain yield among the four farmers were recorded in the treatment STCR-IPNMS 22q ha^{-1} (2175 kg ha^{-1}) followed by STCR-IPNMS 17 q ha^{-1} (1676.3 kg ha^{-1}), GRD (1358.8 kg ha^{-1}) and farmer practices (1106.3 kg ha^{-1}) indicating that the STCR-IPNMS treatment was recorded relatively higher yield over GRD and Farmer's practices (Table 3). Lowest yield recorded in blanket (916.30) compare to all other treatments. STCR-IPNMS 22 t ha^{-1} recorded a yield increase of 49.13% over Farmer's practices. All the treatments are significantly different in which STCR-IPNMS 22 q ha^{-1} receive highest mean yield. In all the four verification trials, the per cent achievement of the targeted yield was within ±10% variation proving the validity of the equations for prescribing integrated fertilizer doses for Pea. The highest net benefit was found in STCR-IPNMS 22q ha^{-1} (Rs. 45639.58) followed by STCR-IPNMS 22 q ha^{-1} (Rs. 26665.10 Rs), GRD (Rs. 14414.40) and farmer practices (Rs. 5907.20). Compare to net benefit, highest B:C ratio was recorded in STCR-IPNMS 22 q ha^{-1} (7.92) followed by STCR-IPNMS 17q ha^{-1} (6.78). The low B:C ratio in STCR-IPNMS 17q ha^{-1} may be due to law of diminishing return in

which quadratic type of response curve are found for added nutrient. So in STCR-IPNMS 22q ha^{-1} we obtain a higher yield compare to STCR-IPNMS 17 q ha^{-1} but economic return is less. So STCR-IPNMS treatments obtain higher yield, net benefits and B:C ratio compare to control and blanket treatments due to balanced supply of nutrients from fertilizer, efficient utilization of applied fertilizer nutrients in the presence of organic sources and the synergistic effect of the conjoint addition of various sources of nutrients (Sellamuthu *et al.* 2015 [11]; Muralidharudu *et al.* 2011 [4] and Singh and Singh, 2014 [12].

Table 3: Grain yield, net benefits and B: C ratio of pea crop under different locations

Treatments	Grain yield (kg ha^{-1}) Locations				Mean (kg ha^{-1})	% increment in yield over T_2	Value of additional yield (Rs.)	Cost of fertilizer (Rs.)	Net benefit (Rs.)	B/C ratio
	1	2	3	4						
T_1-0-0-0	900	930	900	935	916.3	-	-	-	-	-
T_2-10 -20-15	1195	1120	1080	1030	1106.3	-	7600	1692.8	5907.20	3.49
T_3-20-40-30	1335	1375	1340	1385	1358.8	-	17700	3385.6	14414.4	4.26
T_4-19-27-20	1450	1480	1435	1465	1457.5	7.64	21650	2374.4	15837.3	6.67
T_5-40-43- 41	1900	1925	1900	1950	1918.8	40.00	40100	4191.0	32689.8	7.80
T_6-27-32- 26-2	1670	1695	1655	1685	1676.3	23.27	30400	3934.9	26665.1	6.78
T_7-46-48-48- 2	2190	2215	2130	2165	2175.0	61.09	50350	5760.4	45639.6	7.92
C. D. (P=0.05) SEm±	-	-	-	-	48.05 16.04					

Note: Pea@Rs.40.00 kg^{-1}, N@Rs.17.39 kg^{-1}, P_2O_5@Rs.56.25 kg^{-1}, K_2O@Rs.26.66

T_1 – Control, T_2- Farmer's Practices, T_3- GRD (General recommended Dose), T_4- Target yield (15 q ha^{-1}), T_5 Target Yield (20 q ha^{-1}) T_6- Target yield (17 q ha^{-1}) with FYM 2 t ha^{-1}, T_7- Target Yield (22 q ha^{-1}) with FYM 2 t ha^{-1}.

Post harvest soils value revealed that a sufficient build up and maintenance of SN, SP and SK are found under STCR-IPNMS study compare to farmer practices and general recommended dose. Despite removal of higher amount of nutrient in STCR- IPNMS treatment due to getting a higher yield, higher post harvest soil fertility was observed in STCR-IPNMS plot. Highest post harvest soil nitrogen was found in STCR-IPNMS for 22 q ha^{-1} in location-4, Smt. Lalti w/o Jayshankar (245.33 kg ha^{-1}), soil potassium in location-2, Smt. Shankuntla devi w/o Sri Devnarayan (240.00 kg ha^{-1}), soil phosphorus in in location-4, Smt. Lalti w/o Jayshankar (35.20 kg ha^{-1}) table 4. The greater build up of nutrient in STCR- IPNMS treatment was due to balance application of chemical fertilizer in conjunction with organic manure. Combined application of FYM and inorganic fertilizers improved the chemical and physical properties, which may lead to enhanced and sustainable production Tilahun *et al.* (2013) [14]. Greater profit consistent with maintenance of soil fertility status was realized when fertilizer was applied for appropriate yield targets in succession over years using STCR-IPNMS concept (Ramamoorthy and Velayutham, 2011) [7].

Table 4: Post-harvest soil fertility as influenced by various treatments under different locations

Treatments	Location 1 (Kg ha^{-1})			Location 2 (Kg ha^{-1})			Location 3 (Kg ha^{-1})			Location 4 (Kg ha^{-1})		
	SN	SP	SK	SN	SP	SK	SN	SP	SK	SN	SP	SK
T_1	179	25.2	180	167	25.9	183	185	27.0	186	188	28.6	186
T_2	185	27.4	185	180	27.2	188	190	28.0	192	195	29.1	192
T_3	192	28.5	190	185	28.1	195	195	28.5	197	203	31.0	197
T_4	195	28.6	195	190	29.1	200	200	28.8	207	210	31.9	207
T_5	200	30.6	167	195	30.0	205	205	29.0	215	215	32.2	215
T_6	229	32.4	220	220	32.5	224	225	30.0	222	230	34.0	222
T_7	234	33.5	230	235	34.0	240	235	32.2	238	245	35.2	238
Mean	202	29.4	195	203	29.5	205	205	28.9	208	212	29.5	208
C.D (p=0.05)	2.64	0.61	39	0.60	0.63	0.77	0.19	0.39	3.97	0.62	0.44	3.97
S.Em ±	0.85	0.19	12.7	0.19	0.20	0.25	0.06	0.13	1.28	0.19	0.14	1.27

Note: SN=soil available nitrogen, soil available phosphorus and soil available potassium

Ultimately, the highest grain yield was recorded in STCR-IPNMS for 22 q ha^{-1} and lowest for blanket application treatment. The highest percent increment in yield over farmer practices is found in 22 q ha^{-1} STCR-IPNMS treatment. The highest benefit cost ratio obtained in STCR-IPNMS for 22 q ha^{-1} although yield was higher in STCR-IPNMS 17 q ha^{-1}. At high dose of fertilizer, increment in yield become smaller and smaller and they follow quadratic type of response curve. So our fertilizer prescription equation for eastern plain zone of Utter Pradesh is more beneficial and economical for yield targeting of 22 q ha^{-1} under Integrated Plant Nutrition Management System. The per cent achievement of the targeted yield of all the four verification trials was within±10% variation proving the validity of the fertilizer prescription equation for maize. The post harvest available soil nutrient status was very good in STCR-IPNMS treatment over the other treatment which is helpful to maintain the soil fertility status and sustainable production. So we can suggest STCR-IPNMS equation for yield targeting of 22 q ha^{-1} for eastern plain zone of Utter Pradesh for improvement of soil health and sustainable production.

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