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Validation of Soil Test Based Fertilizer Prescription Model under Integrated Plant Nutrient Management System for Maize in an Inceptisol of Varanasi, India

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Studies on Soil test Crop Response based Integrated Plant Nutrient Management System (STCR - IPNMS) were conducted for the desired yield targets of maize, on Inceptisol of Agricultural Research Farm, Banaras Hindu University, Varanasi during *kharif* 2012. 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 location 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 30 and 35 q ha^{-1} with 5 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 maize. The highest per cent increment in yield was recorded in the yield target of 35 q ha^{-1} (51.27 percent) followed by 30 q ha^{-1} (31.43 percent) over farmer's practice. The highest mean grain yield was recorded in STCR-IPNMS–35 q ha^{-1} (4008 kg ha^{-1}). The highest benefit: cost ratio (4.44) was recorded in STCR-IPNMS 30 q ha^{-1} is followed by STCR-IPNMS 35 q ha^{-1} (3.58). The fertilizer prescription equations developed for maize under IPNMS can be recommended for alluvial Inceptisol of eastern Utter Pradesh for achieving a yield target of 30 q ha^{-1} with higher economic return.

Key words: Fertilizer prescription, STCR-IPNMS, Maize, B:C Ratio, yield target etc.

Maize (*Zea mays* L.) is a miracle crop emerging as the third most important cereal crop in the world after wheat and rice, both as food for human consumption and as a feed for live stock. Maize has high genetic yield potential than other cereal crops. Hence it is called as 'miracle crop' and also as 'queen of cereals'. Being a C4 plant, it is very efficient in converting solar energy in to dry matter. It is considered that maize was one of the first plants cultivated by farmers between 7000 and 10,000 years ago, with evidence of maize as food coming from some archaeological sites in Mexico where some small corn cobs, estimated at more than 5000 years old, were found in caves. Maize contains about 72% starch, 10% protein, and 4% fat, supplying an energy density of 365 Kcal 100g^{-1} as compared to rice and wheat, but has lower protein content Ranum *et al.* (2014). In 2013-14 India accounting the production of maize is 24.26

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MT with area of 9.07 mha (Directorate of Economics and Statistics). The current level of maize yield in the country is far behind the global average of 5 M ha^{-1}, and there is a huge scope for improvement in yield.

Indian agriculture is operating on a net negative balance of plant nutrients at the rate of 10 million tonnes per annum Ramakrishna *et al*. (2012). 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). 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) outlined the relationship between soil available nutrients and yield. Ramamoorthy *et al.* (1967) 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) 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 maize 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 maize developed by STCR-IPNMS model, field experiment were carried out in four location of inceptisol of eastern plain zone of Utter Pradesh. Experiments were set up at 4 location viz., larha, Jhariyawan, Hadahi and Aurawantand 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). Electrical conductivity was determined extract using Conductivity Bridge and expressed as dSm^{-1} (Jackson 1973), organic carbon (Walkely and Black,1934), alkaline $KMnO_4$-N (Subbiah and Asija, 1956), Olsen-P (Olsen *et al*., 1954), NH_4OAc-K (Hanway and Heidal, 1952). The initial soil fertility status for different locations is shown in Table 1. Fertilizer prescription equations developed for maize under STCR- IPNMS on eastern plain zone of utter Pradesh, are given below:

$$FN=12.69\,T - 1.27\,SN - 0.59\,ON$$
$$FP_2O_5 = 3.92\,T - 4.25\,SP - 0.67\,OP$$
$$FK_2O = 6.25\,T - 0.76\,SK - 0.39\,OK$$

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-IPNMS based fertilizer dose for an yield target of 30 q ha^{-1}, (v) STCR-IPNMS based fertilizer dose for an yield target of 35 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.

Treatments (IV) and (V) received FYM @ 5 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.

RESULTS AND DISCUSSION

The highest mean grain yield among the four locations were recorded in the treatment STCR-IPNMS 35q ha^{-1} (4008 kg ha^{-1}) followed by STCR-IPNMS 30 q ha^{-1} (3483 kg ha^{-1}), GRD (3275 kg ha^{-1}) and farmer practices (2650 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 (1716) compare to all other treatments. STCR-IPNMS 35 t ha^{-1} recorded a yield increase of 51.27% over Farmer's practices. All the treatments are significantly different in which STCR-IPNMS 35q 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 maize. The highest net benefit was found in STCR-IPNMS 35q ha^{-1} (30467.2 Rs) followed by STCR-IPNMS 30 q ha^{-1} (24512.1 Rs), GRD (19878.1 Rs) and farmer practices (11242.6 Rs). Compare to

Table 1. Initial soil fertility status of the different location of Naugarh block

S. No.	Locations/ villages	pH	E.C. (dS m^{-1})	OC (%)	Avai. N (kg ha^{-1})	Avai. P (kg ha^{-1})	Avai. K (kg ha^{-1})
1.	Larha	7.0	0.30	0.65	184.00	13.50	180.00
2.	Jhariyawan	7.6	0.30	0.70	180.00	15.00	178.00
3.	Hadahi	7.5	0.32	0.71	178.00	15.50	180.00
4.	Aurawantand	7.4	0.30	0.68	180.00	14.50	185.00

Table 2. Fertilizer doses (kg ha^{-1}) imposed in different locations of Naugarh block

S.	Treatments	Larha			Jhariyawan			Hadahi			Aurawantand		
No		N	P	K	N	P	K	N	P	K	N	P	K
1.	Control	0	0	0	0	0	0	0	0	0	0	0	0
2.	Farmer's practice	100	35	35	100	35	35	100	35	35	100	35	35
3.	GRD	120	60	60	120	60	60	120	60	60	120	60	60
4.	STCR-IPNMS* 30 q ha^{-1}	97	34	35	97	34	35	97	34	35	97	34	35
5.	STCR-IPNMS* 35 q ha^{-1}	160	53	66	160	53	66	160	53	66	160	53	66

GRD – General recommended dose
*FYM @5 t ha^{-1}

Table 3. Grain yield, net benefits and B : C ratio of maize under different location

Treatments	Grain yield (Kg ha^{-1})				Mean (Kg ha^{-1})	Percent increment in yield over Farmer practice	Value of additional yield (Rs.)	Cost of fertilizer (Rs.)	Net benefit (Rs.)	B/C ratio
	Larha	Jhariyawa	Hadahi	Aurawant						
T_1-0-0-0	1666	1566	1766	1866	1716	-	-	-		
T_2-100-35-35	2600	2666	2666	2666	2650	-	15869.5	4626.9	11242.6	2.43
T_3-120-60-60	3200	3300	3300	3300	3275	23.60	26503	6624.9	19878.1	3.00
T_4-97-34-35	3510	3520	3450	3450	3483	31.43	30030.5	5518.4	24512.1	4.44
T_5-160–53-66	4033	4033	4033	3933	4008	51.27	38964	8496.8	30467.2	3.58

C.D (P=0.05)=114.54
SEm± = 47.02
Note: Maize@Rs.17.00 kg^{-1}, N@Rs.17.39 kg^{-1}, P_2O_5@Rs.56.25 kg^{-1}, K_2O@Rs.26.66 kg^{-1} FYM@20paise kg^{-1}
T_1 – Control, T_2- Farmer's Practices, T_3- GRD (General recommended Dose)
T_4- Target yield (30 q ha^{-1}), T_5- Target Yield (35 q ha^{-1})

net benefit, highest B:C ratio was recorded in STCR-IPNMS 30 q ha^{-1} (4.44) followed by STCR-IPNMS 35q ha^{-1} (3.58). The low B:C ratio in STCR-IPNMS 35q 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 35q ha^{-1} we obtain a higher yield compare to STCR-IPNMS 30 q ha^{-1} but economic return is less. So STCR-IPNS 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; Muralidharudu *et al.* 2011 and Singh and Singh, 2014.)

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 35 q ha^{-1} in Hadah (222 kg ha^{-1}), soil potassium in Larha (220 kg ha^{-1}), soil phosphorus in Aurawantand (22 kg ha^{-1}) table 4. The greater build up of nutrient in STCR- IPNMS treatment was due to balance application of chemical fertilizer in conjuction with organic manure. Combined application of FYM and inorganic fertilizers improved the chemical and physical properties, which may lead to enhanced and sustainable production Tadesse *et al.* (2013). 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).

Table 4. Post-harvest soil fertility as influenced by various treatments under different location

Treatments	Larha			Jhariyawa			Hadahi			Aurawantand		
	SN	SP	SK	SN	SP	SK	SN	SP	SK	SN	SP	SK
	(Kg ha^{-1})			(Kg ha^{-1})			(Kg ha^{-1})			(Kg ha^{-1})		
T_1	160.00	9.50	155.00	165.00	11.00	150.00	165.00	10.00	180.00	175.00	12.50	160.00
T_2	170.00	11.00	160.00	161.00	10.00	165.00	160.00	12.00	175.00	178.00	12.00	165.00
T_3	165.00	13.50	170.00	185.00	15.00	175.00	182.50	14.50	170.00	171.00	16.00	185.00
T_4	205.00	16.50	195.00	200.50	19.50	195.00	210.00	14.00	195.00	205.00	17.80	202.00
T_5	217.00	17.20	220.00	195.00	19.00	211.00	222.00	18.50	213.00	190.00	22.00	213.00
Mean	183.40	13.54	180.00	181.3	14.90	179.20	187.90	13.80	186.60	183.80	16.06	185.00
C.D (p=0.05)	25.79	3.35	27.16	17.66	4.39	24.15	27.31	3.17	17.47	13.81	4.11	22.90
S.Em ±	6.45	0.84	6.79	4.41	1.10	6.04	6.83	0.79	4.37	3.45	1.03	5.73

Ultimately, the highest grain yield was recorded in STCR-IPNMS for 35 q ha^{-1} and lowest for blanket application treatment. The highest percent increment in yield over farmer practices is found in 35 q ha^{-1} STCR-IPNMS treatment. The highest benefit cost ratio obtained in STCR-IPNMS for 30 q ha^{-1} although yield was higher in STCR-IPNMS 35 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 30 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 30 q ha^{-1} for eastern plain zone of Utter Pradesh for improvement of soil health and sustainable production.

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