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Development of fertilizer prescription targeted yield equation for soya (*Anethumgraveolens* L.) crop based on soil test values in an Inceptisol

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ABSTRACT

A field experiment was conducted on an Inceptisol, Agricultural Research Farm, Banaras Hindu University, Varanasi during rabi 2019-20to develop a targeted yield equation for soya (Anethumgraveolens L.)crop on the basis of STCR approach. The aim of study was to develop fertilizers recommendation equation for cultivation of soya. Soil test data, soya grain yield and NPK uptake by soya crop were used for achieving four important basic parameters, viz., nutrients required to produce one quintal of soya grain (NR), contribution of nutrients from fertilizers (%CF), contribution of nutrients from soil (%CS) and contribution of nutrients from organic matter-FYM (%C-OM). It was found that 4.13, 0.81 and 7.53 kg of N, P_2O_5 and K_2O, respectively were required for producing one quintal soya grain yield. The per cent contribution of nutrients from soil, fertilizer and FYM were 9.47, 61.03 and 3.42 for N; 32.00, 52.82 and 2.22 for P_2O_5 and 35.70, 130.94 and 9.26 for K_2O, respectively. By using these basic parameters, ready reckoner of fertilizer doses was prepared for varying soil test values and desired yield targets of soya grain yield using NPK alone and NPK with FYM.

Key words: Soya, nutrient, grain yield, STCR, fertilizer, basic parameter, FYM

INTODUCTION

Soya (*Anethumgraveolens* L.) is an important seed spice crop mainly grown in *rabi* season and belongs to family Apiaceae.Soya seed are used, both as such and in ground form for its application as a condiment in soups, salads, processed meat, sausages, sauces and pickling. Both seed and oils are used in formulation of various used in Indian Ayurvedic and Unanimedicinal preparation. The gripe water is prepared from its seed, which is used to improve digestion and control vomiting in infants and children. It is cultivated commercially in Rajasthan, Gujarat, Andhra Pradesh, Madhya Pradesh and Utter Pradesh states of India.The farmyard manure (FYM) plays an importantrole in increasing crop yields.It also supplies nitrogen, phosphorus and potassium in available forms to the plants through biological decomposition. Indirectly it improves physical properties of soil such as aggregation, permeability and water holding capacity. It contains all the essential elements which mitigate the ill effect of imbalanced use of fertilizers.Farmers are using excess chemical fertilizers to achieve higher yield but the decision on fertilizer use requires knowledge of the expected crop yield and response to nutrient application. It is a function of crop nutrient needs, supply of nutrients from indigenous sources and the shortterm and longterm fate of the applied fertilizer nutrients (Dobermann*et al.* 2003). Hence, there is a scope to increase the production of soya by soil test crop response (STCR) correlation method. In STCR, the fertilizer doses are recommended based on fertilizer adjustment equations which are developed after establishing significant relationship between soil test values and the added fertilizers. Fertilizers recommendation based on STCR concept are more quantitative, precise and meaningful because combined use of soil and plant analysis are involved in it. The objective of this study was to evolve the sound basis of fertilizer prescriptions for field soyacrop in alluvial soil (Inceptisol) at different soil fertility levels under the conditions of fertilizer scarcity and to ensure maximum fertilizer use efficiency. The study also intended to find the relationship between the nutrients supplied by the soil and added by organic and inorganic sources, their uptake and to develop a guideline for judicious application of fertilizer for desired yield target of soya by using STCR model.

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MATERIALS AND METHODS

Afield experiment was conducted taking soya as test crop during *rabi* eason of 2019-20 on alluvial soil (Inceptisol) of Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi to develop targeted yield equations following the procedure of Ramamoorthy *et al.* (1967). In 2019, selected site of 1245.6 m^2 dimension was divided into three strips of equal size and in each strip, different fertilizer doses, low - 0, 0, 0, medium – 120, 60, 60 and high – 240, 120, 120 kg $ha^{-1}$of N, P_2O_5 and K_2O, respectively were applied to develop a fertility gradient, and sorghamvariety deshichari was grown as an exhaust crop during *kharif* 2019 for stabilizing fertility gradient. The crop was harvested at maturity in the succeeding season; field soyavariety NRCSS-AD-2 was grown as test crop during *rabi* 2019-20 in the same field in which the fertility gradient stabilizing experiment was conducted. Each strip (made in the fertility gradient stabilizing experiment in the previous season) was divided into 24 (21 treated and 3 control plots) equal sized (2 m x 2 m) plots resulting in total of 72 (24 x 3) plots. Three blocks (A, B, C) comprising of 8 treatments were made within each strip randomized with farm yard manure levels. Treatments of N, P_2O_5, K_2O and FYM were used as shown in table 1. The fertilizers used were urea, single superphosphate and muriate of potash. Full doses of P_2O_5 and K_2O were applied as basal while nitrogen was applied in two equal splits, half as basal and remaining half at 30 days after sowing. Plot-wise nutrient levels were tested before applying FYM and NPK. Soil samples (0-15cm) from all the 72 plots were collected and analyzed for available N, available P and available K by adopting standard methods (Jackson, 1973).Soya grain and straw yields were recorded separately at maturity, and grain and straw samples were analysed for N, P and K content and uptake was calculated. Plot wise soil test data, fertilizers doses, yield and uptake were used for obtaining NR (Nutrient required to produce a quintal of soya grain), % CS (Percent contribution of nutrients from soil), % CF (Percent contribution of nutrients from fertilizers) and %C-OM (Percent contribution of nutrients from Organic Matter)., as per method described by Ramamoorthy*et al.* (1967).

Table 1**:** Levels of nitrogen, phosphorus, potassium and FYM used in experiment

N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	FYM (t ha^{-1})
0	0	0	0
30	15	10	5
60	30	20	10
90	45	30	-

These parameters were used to developequations for soil test-based fertilizer recommendations for desired yield targets of linseed under NPK alone as well as NPK + FYM.

RESULTS AND DISCUSSION

Soil available nutrients and grain yield

The range and mean values of soil available nutrients and grain yield of field soyain treated and control plots are furnished in Table 2. In the NPK treated plots (plots that received NPK alone or NPK plus FYM), $KMnO_4$-N increased from 220.9 kg ha^{-1} in strip I to 246.3 kg ha^{-1} in strip III with a mean value of 233.6 kg ha^{-1}. The Olsen-P ranged from 13.1 kg ha^{-1} in strip I to 23.4 kg ha^{-1} in strip III with a mean value of 18.2 kg ha^{-1}, while the NH_4OAc -K status varied from 191.5 kg ha^{-1} in strip I to 233.4kg ha^{-1} in strip III with a mean value of 212.4 kg ha^{-1}. In the NPK treated plots that received NPK alone or NPK plus FYM, the yield of soya ranged from 8.88to17.78 ha^{-1} with a mean value 13.33 q ha^{-1}.In the control plots, the yield ranged from 7.52to9.12 q a^{-1} with a mean value of 8.32 q ha^{-1}.

Table 2**:** Available nutrients in pre-sowing surface soil and yield of soyacrop

Parameters	NPK treated plots		Control plots	
	Range	Mean SEm±	Range	Mean SEm±
KMnO4-N (kg ha^{-1})	220.9 – 246.3	233.6 ± 1.05	201.9 – 227.4	214.6 ± 1.94
Olsen-P (kg ha^{-1})	13.1 – 23.4	18.2 ± 0.36	12.4 – 18.8	15.6 ± 0.54
NH4OAc-K (kg ha^{-1})	191.5 –233.4	212.4 ± 1.43	184.9 – 212.2	198.5 ± 2.07
yield (q ha^{-1})	8.88 – 17.78	13.3 ± 0.29	7.52 – 9.1	8.3 ± 0.11

In the overall control plot of three fertility gradients (Table 2), the $KMnO_4$ -N ranged from 201.9 to 227.4 kg ha^{-1} with a mean of 214.6 kg ha^{-1}, Olsen-P status ranged from 12.4 to 18.8 kg ha^{-1} with a mean value of 15.6 kg ha^{-1}, and the NH_4OAc -K status varied from 184.9–212.2 kg ha^{-1} with a mean value of 198.5 kg ha^{-1}. Though these soils are considered as fertile, they are low in nitrogen and humus and medium in phosphorus and potassium. The above data clearly indicated the existence of operational range of soil test values for available N, P and K status and yield of treated and control plots, which is a prerequisite for calculating the basic parameters and fertilizer prescription equations for calibrating the fertilizer doses for specific yield targets. The equations are:

NPK Alone

FN = 6.77* T – 0.16* STVN
FP_2O_5 =1.55* T – 0.61* $STVP_2O_5$
FK_2O 5.75* T – 0.27* $STVK_2O$

NPK + FYM

FN=6.77* T – 0.16* STVN– 0.06*ON
FP_2O_5 =1.55* T – 0.61* $STVP_2O_5$– 0.04*OP_2O_5
FK_2O =5.65* T – 0.27* $STVK_2O$– 0.07*OK_2O
F.N. = Fertilizer N (kg ha^{-1})
FP_2O_5 = Fertilizer P_2O_5 (kg ha^{-1})
FK_2O = Fertilizer K_2O (kg ha^{-1})
T = Yield target (q ha^{-1})
STV= Soil test values (kg ha^{-1})

Where-STVN, STVP and STVK, respectively are alkaline $KMnO_4$ -N, Olsen-P and NH_4OAc -K in kg ha^{-1} and ON, OP_2O_5 and OK_2O are the quantities of N, P_2O_5 and K_2O in kg ha^{-1} supplied through FYM, respectively.

Basic parameters

The basic data viz., nutrient requirement for producing one quintal grain of soya, per cent contribution of nutrients from soil (%CS), fertilizer (%CF) and FYM (%CFYM) have been calculated (Table 3). These basic parameters were used for developing the fertilizer prescription equations under NPK alone and NPK plus FYM. The nutrient requirement of N, P_2O_5 and K_2O were 4.83, 0.80 and 4.10 kg $q^{-1}$of grain, respectively. The % CS and % CF were found to be 9.47 and 32.00for N, 61.03 and 52.42 for P_2O_5 and 35.70and 130.94 for K_2O. Similarly, the per cent contribution of N, P_2O_5 and K_2O from FYM was 3.42, 2.22 and 9.24, respectively. It was noted that contribution of potassium from fertilizer for soya was higher in comparison to soil. This high value of potassium could be due to the interaction effect of higher doses of N, P coupled with priming effect of starter K doses in the treated plots, which might have caused the release of soil potassium, resulting in the higher uptake from the native soil sources by the crop (Ray *et al.* 2000). Similar type of higher efficiency of potassic fertilizer was also reported for coriander by Singh*et al.* (2019a).Contribution of nutrients from FYM is low which might be due to lower mineralization rate of FYM (Singh and Singh, 2014). However, in the case of P_2O_5, the contribution was more from soil than from fertilizer.

Table 3**:** Basic data and fertilizer adjustment equations of soya (NRCSS-AD-2) in Inceptisol

Basic Data	N	P_2O_5	K_2O
Nutrient requirement or (NR) (kg q^{-1})	4.13	0.81	7.53
Soil efficiency (%) or %CS	9.47	32.00	35.70
Fertilizer efficiency (%) or %CF	61.03	52.42	130.94
Organic efficiency (%) or %CFYM	3.42	2.22	9.24

Fertilizer use following these equations is more economical and environment friendly. For example, to obtain yield targetof 15 qha^{-1} of soya(Table 4), for achieving this target with soil test values of 180:10:140 kg ha^{-1} of $KMnO_4$ -N, Olsen-P and NH_4OAc -K, the fertilizer N, P_2O_5 and K_2O doses required were 72.75,17.15 and 48.45 kg ha^{-1}, respectively. When FYM (0.50, 0.30 and 0.50 per cent of N, P and K, respectively) was applied @ 10 t ha^{-1}along with NPK, the required fertilizer N, P_2O_5 and K_2O doses were 69.75, 15.95 and 45.65 kg ha^{-1}, respectively.Under integrated nutrient management systemthe required dose of fertilizer is low due to nutrient availability increased by FYM through mineralization. Singh*et al.* (2014) and Singh*et al.* (2017) also reported that under integrated nutrient management system, required dose of fertilizer to achieve desired yield target are reduced.

Table 4: Estimation of soil test based fertilizer recommendation for 15 q ha^{-1} grain yield target of soya crop

Soil test values (kg ha^{-1})			Fertilizer doses (kg ha^{-1}) under NPK alone			Fertilizer dose (kg ha^{-1}) under NPK+ FYM @ 10 t ha^{-1}		
STVN	STVP$_2$O$_5$	STVK$_2$O	FN	FP$_2$O$_5$	FK$_2$O	FN	FP$_2$O$_5$	FK$_2$O
180	10.0	140	72.75	17.15	48.45	69.75	15.95	45.65
200	15.0	160	69.55	14.10	43.05	66.55	12.90	40.25
220	20.0	180	66.35	11.05	37.65	63.35	9.85	34.85
240	25.0	200	63.15	8.00	32.25	60.15	6.80	29.45
260	30.0	220	59.95	4.95	26.85	56.95	3.75	24.05

Fertilizer prescription equations were transformed into ready reckoner for requirements of fertilizer, say for yield target of15 q ha^{-1} of soya on soils with varying soil test value for both NPK applied with and without FYM.The finding revealed that with the variation in soil test values, the rate of fertilizer recommendations varied for the same level of crop production. Hence balanced fertilization through soil testing becomes essential for increasing crop production. Similar results were found by Singh *et al.*(2015) in maize and Singh *et al.* (2018) in lentil.It is obvious from these findings that there was net saving of fertilizers in each target and ultimately to reduce cost of cultivation.

Prediction of post-harvest soil available nutrients (N, P and K)

A Post-harvest prediction equation of soil test value can be used to make a fertilizer recommendation for entire cropping scheme. This is very useful because the soil of farmers' fieldunder intensive farmingcannot be tested for each crop for practical reasons. The interactionsamong thepost-harvest soil test values, fertilizer applied doses, initial soil test values and grain yield from the treated plots for soyacrop are obtained in Table 5.

Table 5:Prediction equations for post-harvest soil test value for soya

Nutrient	R^2	Multiple regression equation
N	0.88**	38.63102-1.00819RY**+0.895446SN**+0.06684 FN*
P	0.83**	1.959867+0.49331RY*+1.113884SP**+0.018820 FP**
K	0.70**	67.61420-0.075365RY**+0.773849SK**-0.097950 FK

** Significant at 1 % level: Here PHN, PHP and PHK stand for the post-harvest soil test values of N, P and K (kg ha^{-1}); RY is the yield of crop (q ha^{-1}), SN, SP and SK represent the initial soil test values of N, P and K (kg ha^{-1}) and FN, FP and FK represent the fertilizer doses of N, P_2O_5 and K_2O kg ha^{-1} applied*

Noticeably large R^2 values (significant at 1%) were obtained for these equations. This suggests that such regression equations can be applied with confidence for the prediction of available N, P, and K after soya for making soil test based fertilizer recommendation for succeeding crops. Similar significances were also found by Singh*et al.* (2019) for the three major nutrients.

Equations developed could be used for making fertilizer recommendation for targeted yields of soya in Inceptisols of eastern Uttar Pradesh. Fertilizer recommendations based on this concept are more quantitative, precise and meaningful because combined use of soil and plant analysis is involved in it. Farmers can choose the yield target according to their resources and management conditions. It is also advocated that the trends observed in this study may hold true for broad generalization in the larger parts of the Gangetic eastern plains that would serve as potent guide for efficient fertilizer management sustainably.

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