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Fertilizer recommendation based on soil testing for the targeted yield of coriander (*Coriandrum sativum* L.) in an Inceptisol

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ABSTRACT

Soil Test crop response correlation studies on coriander (Coriandrum Sativum L.) based on targeted yield approach was conducted on Inceptisol of Agricultural Research Farm, Banaras Hindu University, Varanasi during rabi 2018-19 by using integrated plant nutrient management system through which fertilizers recommendation equation for coriander may be achieved. Soil test data, coriander grain yield and NPK uptake by coriander crop were used for achieving four important basic parameters, viz., nutrients required to produce one quintal of coriander grain (NR), contribution of nutrients from fertilizers (%CF), contribution of nutrients from soil (%CS) and contribution of nutrients from organic matter-FYM (%C-OM). Results revealed that 4.83, 0.80 and 4.10 kg of N, P_2O_5 and K_2O, respectively were required for producing one quintal coriander grain yield. The per cent contribution of nutrients from soil, fertilizer and FYM were 21.17, 56.63 and 9.56 for N; 60.86, 39.25 and 2.38 for P_2O_5 and 25.50, 114.41 and 5.22 for K_2O, respectively. Based on this information fertilizer prescription equations were developed to predict fertilizer recommendation for obtaining specific yield target of coriander. Incorporation of farmyard manure enhanced the recovery of nutrients considerably. After the verification of these equations at farmer's fields, these can be used for fertilizer recommendations in Eastern Uttar Pradesh having similar soil and climatic conditions.

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

INTRODUCTION

Coriander (*Coriandrum sativum* L.) is an important seed spice crop mainly grown in rabi season and belongs to family Apiaceae. India is the largest producer of coriander. It is prominently cultivated in Rajasthan, Andhra Pradesh, Gujrat and Madhya Pradesh with scattered pockets in Tamil Nadu, Odisha, Karnataka, Haryana, Uttar Pradesh and Bihar. Rajasthan occupies the premiere position in production and acreage and contributes about 40 per cent to the total production of coriander in India. The tender leaves, stem and fruits of coriander have a pleasant aromatic flavour and thus is indispensable food adjunction in Indian cookery. The seeds are also used as condiment. The medicinal properties of coriander are many used in Indian Ayurvedic and Unani medicinal preparation.

Appropriate and efficient use of fertilizers for getting the maximum crop yield is possible through target oriented fertilizer scheduling which is based on the principles of balanced fertilization of crop. The farmyard manure (FYM) seems to be directly responsible for increasing crop yields either by accelerating the respiratory process by increasing cell permeability by hormone growth action or by combination of all these processes. It supplies nitrogen, phosphorus and potassium in available forms to the plants through biological decomposition. Indirectly it improves physical properties of soil such as aggregation of soil, permeability and water holding capacity. 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 short-term and long-term fate of the applied fertilizer nutrients (Dobermann *et al.*, 2003). Hence, there is a scope to increase the production of coriander by soil test crop response (STCR) correlation method, 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 soil test crop response correlation concept are more quantitative, precise and

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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 coriander crop in alluvial soil (Inceptisol) at different soil fertility levels under the conditions of fertilizer scarcity and to ensure maximum fertilizer use efficiency. No data are available on soil test crop response correlation studies under integrated nutrient management system on coriander particularly in an Inceptisol of Eastern Uttar Pradesh. Therefore the present investigation was carried out to formulate the fertilizer prescription equations for coriander under INM mode.

MATERIALS AND METHODS

A standard field experiment was conducted taking coriander as test crop during *rabi*2018-19 on alluvial soil (Inceptisol) of Agricultural Research Farm, Banaras Hindu University, Varanasi. In 2018, 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 sorghum variety sudan chari was grown as an exhaust crop during *kharif* 2018 for stabilizing fertility gradient. The crop was harvested at maturity in the succeeding season; coriander variety pusa selection-360 was grown as test crop during *rabi* 2018-19 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 super phosphate 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, by the alkaline permanganate method (Subbiah and Asija, 1956); available P, by Olsen *et al.* (1954) and available K, by ammonium acetate method (Hanway and Heidal, 1952). Coriander crop was sown in lines at25 cm apart; having 8 lines in a plot and recommended package of practices were followed. Coriander grain and straw yields were recorded separately, and plant samples were taken for estimation of N, P, and K contents for working out uptake by the crop. With the help of nutrient uptake data, crop yields, soil test values and fertilizer nutrients applied, nutrient requirements in kg q' of grain, per cent contribution of soil and fertilizer nutrients were derived and fertilizer prescription equations were developed. Per cent contribution of farm yard manure for the nutrients was also derived (Chatterjee *et al.,* 2010).

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	-

1. Nutrient Requirement in kg $q^{-1}$of grain (NR) = Total uptake of nutrient (kg ha^{-1}) / Grain yield (q ha^{-1}) in plot

2. Per cent contribution of nutrients from soil (% CS)

$$= \frac{\text{Total uptake of nutrient in control plot (kg ha}^{-1}\text{)}}{\text{Soil test values of nutrient in control plot (kg ha}^{-1}\text{)}} \times 100$$

3. Per cent contribution of nutrients from fertilizer without FYM (% CF)

$$= \frac{\text{Total uptake of nutrient (kg ha}^{-1}\text{) in fertilizer treated plot} - \text{Soil test values (kg ha}^{-1}\text{) of nutrient in fertilizer treated plot X \%CS/100}}{\text{Nutrient dose applied through fertilizer (kg ha}^{-1}\text{)}} \times 100$$

4. Per cent contribution of nutrients from organic manure (%CFYM)

$$= \frac{\text{Total uptake of nutrient (kg ha}^{-1}\text{) in organic manure treated plot} - \text{Soil test values (kg ha}^{-1}\text{) of nutrient in organic plot X \% CS/100}}{\text{Dose of nutrient added through FYM (kg ha}^{-1}\text{)}}$$

These parameters were used to develop equations for soil test based fertilizer recommendations for desired yield targets of field coriander under NPK alone as well as NPK plus FYM.

RESULTS AND DISCUSSION

Soil available nutrients and grain yield

The range and mean values of soil available nutrients and grain yield of field coriander in 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 197.6 kg ha^{-1} in strip I to 251.2 kg ha^{-1} in strip III with a mean value of 224.4 kg ha^{-1}. The Olsen-P ranged from 10.2 kg ha^{-1} in strip I to 20.7 kg ha^{-1} in strip III with a mean value of 15.4 kg ha^{-1}, while the NH_4OAc -K status varied from 180.3 kg ha^{-1} in strip I to 220.3 kg ha^{-1} in strip III with a mean value of 201.4 kg ha^{-1}.

Table 2: Available nutrients in pre-sowing surface soil and yield of Coriander crop

Parameters	NPK treated plots		Control plots	
	Range	Mean SEm±	Range	Mean SEm±
$KMnO_4$-N (kg ha^{-1})	197.6 – 251.2	224.4 ± 1.1	182.6 – 220.3	201.4 ± 2.51
Olsen-P (kg ha^{-1})	10.2 – 20.7	15.45 ± 0.2	9.3 – 13.6	11.4 ± 1.33
NH_4OAc-K (kg ha^{-1})	180.3 – 220.3	200.30 ± 1.4	170.2 – 197.2	183.7 ± 1.80
yield (q ha^{-1})	13.2 – 20.2	16.73 ± 0.19	10.1 – 13.9	12.0 ± 0.25

In the NPK treated plots that received NPK alone or NPK plus FYM, the yield of coriander ranged from 13.20 to 20.25 q ha^{-1} with a mean value 16.73 q ha^{-1}. In the overall control plots, the yield ranged from 10.16 to 13.10 q ha^{-1} with a mean value of 12.00 q ha^{-1}. In the overall 10.10 control plot of three fertility gradients (Table 2), the $KMnO_4$ -N ranged from 182.6 to 220.3 kg ha^{-1} with a mean of 201.4 kg ha^{-1}, Olsen-P status ranged from 9.3 to 13.6 kg ha^{-1} with a mean value of 11.5 kg ha^{-1}, and the NH_4OAc -K status varied from 170.2 to 197.2 kg ha^{-1} with a mean value of 183.7 kg ha^{-1}. Though these soils are considered as fertile, they were low in nitrogen and humus and medium in phosphorus and potassium. These data clearly indicate 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

$FN = 8.53^* T – 0.37^* STVN$

$FP_2O_5 = 2.08^* T – 0.82^* STVP_2O_5$

$FK_2O\ 2.02^* T – 0.10^* STVK_2O$

NPK + FYM

$FN=8.53^* T – 0.37^* STVN– 0.17^* ON$

$FP_2O_5 =2.08^* T – 0.82^* STVP_2O_5– 0.06^*O\ P_2O_5$

$FK_2O =2.02^* T – 0.10^* STVK_2O – 0.05^*OK_2O$

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 coriander, 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 21.17 and 56.63 for N, 60.86 and 39.25 for P_2O_5 and 25.50 and 114.41 for K_2O. Similarly, the per cent contribution of N, P_2O_5 and K_2O from FYM was 9.56, 2.38 and 5.22, respectively. It was noted that contribution ofpotassium from fertilizer for coriander was higher in comparison to soil. This high value ofpotassium 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. Similar type of higher efficiency of potassic fertilizer was also reported for fennel by (Singh *et al.*, 2019). 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 coriander (Pusa selection-360) in Inceptisol

Basic Data	N	P_2O_5	K_2O
Nutrient requirement or (NR) (kg q^{-1})	4.83	0.80	4.10
Soil efficiency (%) or %CS	21.17	60.86	25.50
Fertilizer efficiency (%) or %CF	56.63	39.25	114.41
Organic efficiency (%) or %CFYM	9.56	2.38	5.22

Table 4: Estimation of soil test based fertilizer recommendation for 15 q ha^{-1}grain yield target of coriander 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	$STVP_2O_5$	$STVK_2O$	FN	FP_2O_5	FK_2O	FN	FP_2O_5	FK_2O
180	10.0	140	61.35	15.70	16.30	52.85	13.90	13.80
200	15.0	160	53.95	7.95	14.30	45.45	6.15	11.80
220	20.0	180	46.55	0.20	12.30	38.05	0.00	9.80
240	25.0	200	39.15	0.20	10.30	30.65	0.00	7.80
260	30.0	220	31.75	0.00	8.30	23.25	0.00	5.80

Fertilizer use following these equations is more economical and environment friendly. For example, to obtain yield target of 15 q ha^{-1} of coriander (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 61.35, 15.70 and 16.30 kg ha^{-1}, respectively. When FYM (0.60, 0.35 and 0.55 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 52.85, 13.90 and 13.80 kg ha^{-1}, respectively. Under IPNMS the 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 plant nutrient system, required dose of fertilizer to achieve desired yield target are reduced.

Fertilizer prescription equations were transformed into ready reckoner for requirements of fertilizer, say for yield target of 15 q ha^{-1} of coriander on soils with varying soil test value for both NPK applied with and without FYM. From findings it is obviously that vary with the soil test values, the fertilizer recommendation varies for the same level of crop production. Hence balanced fertilization through soil testing becomes essential for increasing crop production. Similar results were also found by Mishra *et al.* (2015) in chickpea and Singh *et al.*(2015) in maize. 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' field under intensive farming cannot be tested for each crop for practical reasons. The interactions among the post-harvest soil test values, fertilizer applied doses, initial soil test values and grain yield from the treated plots for coriander crop are obtained in Table 5.

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

Nutrient	R^2	Multiple regression equation
N	0.98**	8.80+1.01794RY**+0.956391SN**+0.021064 FN*
P	0.98**	1.890002+0.132757RY*+0.908038SP**+0.00983FP**
K	0.86**	-5.83775 -0.71967RY**+1.212445 SK**-0.13008 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. Suggesting that such regression equations can be applied with confidence for the prediction of available N, P, and K after coriander 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 coriander in Inceptisol of eastern plain zone of Uttar Pradesh. Therefore, fertilizer recommendations based on targeted yield approach is not only valuable for getting desired yield targets but also takes care for efficient and judicious use of fertilizers in increasing coriander production. Validity of these equations will be tested by conducting follow up trials on farmer's fields keeping in view their financial resources. There after these can be used by soil testing laboratories for fertilizers recommendations to farming communities of Eastern Uttar Pradesh.

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