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Soil test based fertilizer recommendation for mustard (*Brassica juncea* L.) in eastern plain zone of Uttar Pradesh, India

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Abstract

To study the soil test based fertilizer recommendation for mustard crop on grain and straw yield, nutrient uptake and soil test data were used for obtaining basic parameter viz., Nutrient requirement, contribution of nutrients from soil, fertilizer and organic manure. It was found that 5.22 kg N, 0.99 kg P₂O₅ and 4.25 kg K₂O were required for producing one quintal of grain. The per cent contribution of soil nitrogen, phosphorus and potassium were 23.94, 70.45 and 22.14 the percent contribution from applied fertilizer were 42.53, 21.44 and 90.52 per cent of nitrogen, phosphorus and potassium respectively. The fertilizer adjustment equation were developed for mustard (var. Shivani) and quantitative estimation of fertilizer doses formulated for a range of soil test values and desired yield targets under NPK alone and with FYM.

Keywords: Soil test based, fertilizer recommendation, mustard (*Brassica juncea* L.)

Introduction

Rapeseed-mustard is the second most important oilseed crop in India. Its production has markedly increased after launching of Technology Mission on Oilseeds. However, its productivity is only 1128 kg ha⁻¹ and in Uttar Pradesh Rapeseed and mustard occupies 1.0 mha area with production of 1.12 mt. in 2013-14 (GOI). Over-exploitation of soils over many decades has resulted in the exhaustion of the agricultural production systems and steadily declining productivity has been noticed in long term experiments in Asia (Bhandari *et al.*, 2002; Latha *et al.*, 2003; Manna *et al.*, 2005) [6, 7]. The decision on fertilizer use requires knowledge of the expected crop yield response to nutrient application, which is a function of crop nutrient needs, supply of nutrients from indigenous sources, and the fate of the fertilizer applied (Dobermann *et al.*, 2003) [3]. The cost of fertilizers has gone up and, hence, their optional use in required quantity mainly depends on resources available to farmers. Imbalanced use of chemical fertilizers results in lower nutrient use efficiency and restricts utilization of the genetic potential of a crop to its maximum. The most comprehensive approach of fertilizer application by incorporating soil test values, nutrient requirement of the crop, contribution of nutrients from soil manures fertilizers and fixing yield targets is possible only through the fertility gradient field experimental technique of Ramamoorthy *et al.*, (1967) [11]. Soil test based application of plant nutrient helps to realize higher response ratio and benefit: cost ratio as the nutrients are applied in proportion to the magnitude of the deficiency of a particular nutrient and the correction of the nutrients imbalance in soil helps to harness the synergistic effects of balanced fertilization (Rao and Srivastava, 2000) [12]. Balanced fertilization can be only option to mitigate this anomaly and it does not only mean the application of right quantity of fertilizers for crop growth, but also the right time, mode and sources of application. The nutrient management strategies involving the use of chemical fertilizers but also supplemented with organic manure and bio fertilizers. The present investigation aimed to study the relationship between the nutrient supplied by the soil and added fertilizers, their uptake and yield of mustard and to develop a guideline for judicious application of fertilizer for maximum production of mustard.

Materials and Methods

A field experiment on Soil test based fertilizer recommendation with mustard (*Brassica juncea* L.) was conducted at Department of Soil Science and Agricultural Chemistry, SHUATS,

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Naini, Uttar Pradesh during *Rabi* 2018- 19. The Selected site of experiment was 52.20 x 20.0 square meter dimensions and was divided into three strips of equal size and the three fertility gradients designated as 0_A, 1_A and 2_A were developed by applying variable amounts of farmyard manure and N, P and K fertilizer. In the main experiment each strip was further sub-divided into twenty seven equal plot of 3x3.5 sq. m size having twenty one treated and three control plots. The mustard was sown in lines 45 cm apart, under selected treatment combinations four level of each N (0, 40, 80 and 120 kg ha⁻¹), P₂O₅ (0, 20, 40 and 60 kg ha⁻¹), K₂O (0, 20, 40 and 60 kg ha⁻¹) and three levels of FYM (0, 5 and 10 t ha⁻¹). Soil sample were taken from surface layer (0-15 cm) from each plot of strip I, II and III before fertilizer treatment application. The samples collected from the field were brought to the laboratory and kept in air drying for laboratory analysis. The initial soil samples were analyzed for organic carbon (Walkley and Blak, 1934) ^[18], Alkaline KMnO₄ oxidizable nitrogen (Subbiah and Asija, 1956), Olsen's phosphorus (Olsen *et al.*, 1954) ^[10] and ammonium acetate extractable potassium (Hanway and Heidal, 1952) ^[4]. At crop maturity, the plot wise yield was recorded and composite plant samples (grain and straw) were collected and processed. These samples were analyzed for total N, P and K contents (Jackson, 1973) ^[5]. These soil test data, plant analysis and grain yield data as given in table 2 were used to develop fertilizer prescription equation as per method described by Ramamoorthy *et al.* (1967) ^[11].

1. Fertilizer requirement equation for target yield through fertilizer only

$$FD = \frac{NR}{\%CF} \times 100T - \frac{\%CS}{\%CF} \times STV$$

2. Fertilizer requirement equation for target yield through fertilizer and FYM

$$FD = \frac{NR}{\%CF} \times 100T - \frac{\%CS}{\%CF} \times STV - \frac{\%CFYM}{\%CF} \times M$$

Where,

FD = Fertilizer dose of nitrogen, phosphorus and potassium in kg ha⁻¹, NR = Nutrient requirement (kg) of nitrogen, phosphorus and potassium, CS = Contribution of nutrients from soil nutrient (%), CF = Contribution of nutrients from applied fertilizer soil nutrient (%), CFYM = Contribution of nutrients from applied organic manure (%), T = Yield target kg ha⁻¹, M = Amount of nutrient applied through FYM (kg ha⁻¹), STV = Soil test values (kg ha⁻¹).

A multiple regression equation was calibrated to predict the expected yield levels under varying levels of nutrients supplied through soil and fertilizers as well as their interactions and is given below as:

$$Y = \pm A \pm b_1 SN \pm b_2 SP \pm b_3 SK \pm b_4 FN \pm b_5 FP \pm b_6 FK \pm b_7 SN^2 \pm b_8 SP^2 \pm b_9 SK^2 \pm b_{10} FN^2 \pm b_{11} FP^2 \pm b_{12} FK^2 \pm b_{13} SN \times SP \pm b_{14} SN \times SK \pm b_{15} SP \times SK$$

Where, Y= crop yield (kg ha⁻¹); A= intercept (kg ha⁻¹); bi= regression coefficient (kg ha⁻¹); SN, SP, SK= available soil nitrogen, phosphorus and potassium (kg ha⁻¹) respectively; FN, FP, FK= fertilizer nitrogen, phosphorus and potassium (kg ha⁻¹) respectively.

Results and Discussion

The experimental field was having wide variability in soil test values which was necessary before conducting this experiment. The strip wise ranges and means of grain yield and soil test values of organic carbon, nitrogen, phosphorus and potassium are given in table 1. The average organic carbon content of entire experimental area, varied from 0.31 to 0.91 percent with a mean of 0.68 percent. The available nitrogen of the entire experimental plots ranged between 195 and 267.38 kg N ha⁻¹, with mean value 239.37 kg N ha⁻¹. The available phosphorus content of the entire experimental field ranged from 14.50 to 28.75 kg P₂O₅ ha⁻¹, with a mean value of 20.29 kg P₂O₅ ha⁻¹. The available potassium ranged from 183.0 to 256.0 kg K₂O ha⁻¹, mean being 221.90 kg K₂O ha⁻¹ for the entire experimental area. The average grain yield in I, II and III strips was recorded as 15.74, and 17.75 q ha⁻¹ and the average straw yield in I, II and III strips was recorded as 43.39, 44.63 and 46.75 q ha⁻¹ respectively.

The basic data regarding calculation of fertilizer doses for targeted yield of mustard is presented in table 2. The nutrient requirement for the production of one quintal of grain 5.22 kg of nitrogen (N), 0.99 kg of phosphorus (P₂O₅) and 4.25 kg of potassium (K₂O) were required. The percentage contribution from soil as its available nutrients in case of nitrogen was 23.94, for phosphorus 70.45 and for potassium 22.14 and the percent contribution from applied fertilizer with FYM was 42.53, 21.44 and 90.52 percent of nitrogen, phosphorus and potassium, respectively.

Avtari *et al.*, (2010) ^[1] were reported 5.08 kg of nitrogen, 1.24 kg of phosphorus and 3.96 kg of potassium required for producing one quintal grain of yellow sarson and the percent contribution of nutrients from soil in case of nitrogen was 33.89, for phosphorus 52.99 and for potassium 16.38 and the percent contribution from applied fertilizer with FYM was 32.50, 51.50 and 101.95 percent of nitrogen, phosphorus and potassium respectively in soils of *tarai* region of Uttar Pradesh. Similar result was also reported by Regar and Singh (2014) ^[13] and Sachan *et al.*, (1981) ^[14]. The following simplified fertilizer adjustment equations was formulated by using basic data to give the fertilizer dose, as a function of targeted yield and soil test values.

With FYM

1. Nitrogen dose (kg ha⁻¹) = 12.27T - 0.56SN - 0.09FYM - N
2. Phosphorus dose (kg ha⁻¹) = 4.60T - 3.29SP - 0.06FYM - P
3. Potassium dose (kg ha⁻¹) = 4.69T - 0.24K - 0.05FYM - K

Without FYM

1. Nitrogen dose (kg ha⁻¹) = 12.27T - 0.56SN
2. Phosphorus dose (kg ha⁻¹) = 4.60T - 3.29SP
3. Potassium dose (kg ha⁻¹) = 4.69T - 0.24K

T = Yield target (q ha⁻¹), SN = Alkaline KMnO₄-N, SP= Olsen's P (kg ha⁻¹) and S_k + Amm. Ac.- K (kg ha⁻¹).

The fertilizer adjustment equations were ready for determining requirement of fertilizer. Say for 18 q ha⁻¹ the yield target of mustard with varying soil test values in table. These results were shows that the fertilizer requirement varies with the soil test values for a particular target yield. Similar result was also reported by Mishra *et al.* (2014) and Singh *et al.* (2014) ^[16].

Table 1: Range and average of mustard yield (q ha⁻¹) and soil test values under different fertility strips

Particulars	Strip I		Strip II		Strip	III
	Range	Mean	Range	Mean	Range	Mean
Grain yield (q ha ⁻¹)	12.0-19.80	15.74±0.43	12.80-20.80	16.65±0.44	13.90-22.50	17.75±0.45
Organic carbon (%)	0.41-0.71	0.54±0.02	0.45-0.83	0.68±0.02	0.65-0.91	0.81±0.01
Alkaline KMnO ₄ -N (kg ha ⁻¹)	195.0-239.07	221.41±2.37	212.0-254.79	239.69±2.18	240.53-267.34	257.02±1.56
Olsen's P (kg ha ⁻¹)	14.50-20.22	17.52±0.32	14.80-22.35	19.03±0.40	19.50-28.75	24.36±0.53
Am. Ac K (kg ha ⁻¹)	183.0-220.12	202.36±2.08	183.0-240.0	220.54±3.04	188.0-256.0	240.81±3.48

Table 2: Basic data for calculating fertilizer doses with and without FYM for targeted yields of mustard

Particulars	Without FYM			With FYM		
	N	P	K	N	P	K
Nutrient requirement (kg) to produce one quintal of mustard grain.	5.22	0.99	4.25	5.22	0.99	4.25
Percent contribution from soil as its available nutrients (CS)*	23.94	70.45	22.14	23.94	70.45	22.14
Percent contribution from applied fertilizer nutrients with FYM(CF)	42.53	21.44	90.52	42.53	21.44	90.52
Percent contribution from applied FYM nutrients (CFYM)	-	-	-	4.02	1.24	4.96

*Soil tests values at (0-15cm depth) Alkaline KMnO₄ -N (kg ha⁻¹), Olsen's-P (kg ha⁻¹) and neutral normal ammonium acetate extractable potassium (kg ha⁻¹)

Table 3: Estimation of soil test based fertilizer recommendation for 18 q ha⁻¹ grain yield target of mustard crop

N	P	K	N	P	K
100	10	100	80	60	40
125	13	125	70	50	35
150	15	150	60	40	30
175	18	175	50	25	25
200	20	200	40	15	15
225	23	225	30	10	10
250	25	250	20	10	10
275	28	275	10	10	10
300	30	300	10	10	10
325	33	325	10	10	10
350	36	350	10	10	10
375	38	375	10	10	10

Table 4: Prediction equations for post-harvest soil test value for mustard crop

Nutrient	Multiple Regression Equation	R ²
N	PHN = 183.65 + 2.197RY ** + 0.096SN ** + 0.154FN *	0.69**
P	PHP = 14.32 + 0.854RY * + 0.404SP ** + 0.0601FP **	0.84**
K	PHK = 131.03 + 3.563RY ** + 0.121SK ** + 0.0735FK	0.89**

Where: SN, SP, SK; soil available nitrogen, phosphorus (P₂O₅) and potassium (K₂O) (kg ha⁻¹); FN, FP and FK; fertilizer nitrogen, phosphorus and potassium (K₂O) required (kg ha⁻¹). RY is relative yield (kg ha⁻¹); **significant at 1% level.

The prediction equation for a post-harvest soil test value can be used to make a fertilizer recommendation for entire cropping system. This is very useful because the soil of farmers' fields under intensive cultivation cannot be tested for each crop for practical reasons. The interaction with the initial soil test values, post-harvest soil test values, fertilizer applied doses and grain yield from the treated plots for mustard crop are presented in table 4. Considerable large R² values (significant at 1%) were obtained. This suggests that such regression equations can be used with confidence for the prediction of available N, P and K after mustard for making soil test based fertilizer recommendation for succeeding crops. Similar results were also found by Singh *et al.*, (2015) [9] and Milap-chand *et al.*, (2006) [8] for the three major nutrients.

In conclusion, targeted yield approach in the present study showed difference in fertilizer requirement of nitrogen, phosphorus and potassium, which needs to be further investigation needed over the farmer's own practice and general fertilizer recommendation. It is also suggested that the trends observed in this study may hold true for broad generalization in the larger parts of the Gangatic eastern plains that would serve as potent guide for efficient fertilizer

management. Involvement of both soil and plant analysis make fertilizer recommendations based on this concept are more quantitative, precise and meaningful. This provides the scientific basis for balanced fertilization and enables farmer to choose target yield according to his resource and management conditions.

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