Journal of the Indian Society of Soil Science, Vol. 69, No. 2, pp 162-170 (2021)
DOI: 10.5958/0974-0228.2021.00037.2

Assessment of Nutrient Requirement for Spring Brinjal (*Solanum melongena* L.) through Soil Test Crop Response Approach on North Indian Mollisol

Pallavi Bhatt*, Sobaran Singh, Pawan Kumar Pant[1], Ramesh Chandra, Poonam Gautam, Lalit Bhatt[2] and Alka Arya

Department of Soil Science, College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar, 263 145, Uttarakhand, India

Soil test crop response (STCR) based fertilizer prescription was carried out on brinjal to optimize the fertilizer doses. The field experiment was conducted at N.E. Borlaug Crop Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar (Latitude 29^o N, Longitude 79^{o}29' E and Altitude of 243.84 m above mean sea level) during spring season of 2017-18 to study the effect of soil and applied nutrients on brinjal to ensure balanced fertilization. Response of brinjal to selected combinations of three levels of FYM (0, 10 and 20 t ha^{-1}), four levels of nitrogen (0, 60, 120 and 180 kg N ha^{-1}), four levels of phosphorus (0, 30, 60 and 90 kg P_2O_5 ha^{-1}) and four levels of potassium (0, 30, 60 and 90 kg K_2O ha^{-1}) in different soil fertility strips was studied. Basic data for fertilizer prescription was computed on the basis of soil analysis, nutrient uptake and fruit yield. Nutrient requirement to produce one quintal of brinjal fruit was 0.464, 0.112 and 0.208 kg N, P_2O_5 and K_2O, respectively. Per cent contribution of available N, P_2O_5 and K_2O was 31.1, 23.1 and 13.2, respectively from soil; 64.8, 89.2 and 82.1, respectively from FYM; 25.4, 22.9 and 18.8, respectively from fertilizer; and 35.1, 33.9 and 36.7 from conjoint use of fertilizer and FYM, respectively. Fertilizer prescription equations were generated by these basic data. These fertilizer prescription equations are valuable for efficient and judicious use of costly fertilizers to improve farmer's economic conditions.

Key words: Soil test crop response, brinjal, soil test values, fertilizer prescription equation and target yield

Worldwide, the ubiquity of hunger has declined to 795 million in 2015 (FAO 2015), due to advancement in safeguarding adequate approach to staple foods as measured in terms of caloric intake. However, on an estimate about 2 billion people are affected by insufficient intake of micronutrients (WHO 2016) and further 2.1 billion people are overweight or obese (Ng *et al.* 2014). Vegetables are essential source of micronutrients needed for healthier diet and have an influential value in human nutrition, chiefly high in vitamins, minerals, dietary fibres and phytochemicals, and reduce risk from dangerous diseases and other medical problems. Three-fourth of the world's production of vegetables occurs in Asia and China being the largest producer with production of 554.3 million tonnes (Mt). While India is the second largest producer of fresh vegetables worldwide in 2017 with production of about 127.1 Mt. In India, vegetables accounts for about an area of 10.383 million hectares (Mha) with an annual production of 179.7 Mt and the productivity of 17.3 t ha^{-1} (Fertiliser and Agriculture Statistics Northern Region 2017-18). Owing to its better adaptability brinjal (*Solanum melongena* L.) is grown in tropical and subtropical regions of the world. In Uttarakhand, cultivation of brinjal is done in an area of about of 2.33 thousand hectares with production of about 27.12 thousand Mt (National Horticulture Production Database 2012-13).

Brinjal has less nutritive value, as it contains 92.7 g moisture, 1.4 g protein, 0.30 g fat, 0.30 g

*Corresponding author (Email: pallavibhatt1993@gmail.com)
Present Address
[1]Soil and Land Use Survey of India, Department of Agriculture, Cooperation and Farmers Welfare, New Delhi, 110 012, India
[2]Department of Vegetable Science, College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar, 263 145, Uttarakhand, India

minerals, 0.30 g fibre, 4.0 g carbohydrates, 18.0 mg calcium (Ca), 18.0 mg oxalic acid, 47.0 mg phosphorus (P), 2.0 mg potassium (K), 124 I.U vitamin A, 0.11 mg riboflavin and 12.0 mg vitamin C per 100 g of edible portion (Choudhary 1976). Despite of the low nutritional value, brinjal forms an important part of cuisine across the world. Since the fruit is able to absorb large amounts of sauces and cooking fats, it is used in preparing very rich dishes.

Fertilizer is among one of the key inputs which is being used in agriculture. In order to optimize its proper use, there must be balanced application of fertilizers. Efficient and economic use of fertilizers would help in increasing the production and decreasing input cost for obtaining maximum return. Different methods and approaches have been used to get workable bases for predicting fertilizer requirements of the crops, out of these the most widely used approaches are (1) generalized recommendation, (2) soil test rating and fertilizer adjustment (Muhr *et al*. 1965), (3) critical level of nutrient in soil or sufficiency concept (Cate and Nelson 1965), (4) recommendation for certain percentage of yield maximum (Bray 1954), (5) fertilizer recommendation based on targeted yield (Troug 1960; Ramamoorthy *et al*. 1974), (6) fertilizer recommendation for maximum and economic yield based on regression equation between yield and soil test (Ramamoorthy *et al.* 1967).

Soil test crop response (STCR) based prescription is gaining popularity due to its superiority over general fertilizer recommendations. Soil test crop response approach for targeted yield is distinctive in the way that this method not only stipulate the soil test based fertilizer dose, but also the level of yield the farmer can desire to achieve if good agronomic practices are adopted in raising the crop. Continual use of inorganic nutrients may affect the physicochemical properties of soil and thereby affect the crop yield. In order to sustain the yield and reduce the reliance on inorganic fertilizer use, conjunctive use of organic manures, biofertilizers and fertilizers is very much needed. Integrated nutrient management (INM) is a system/approach which mainly foregrounds the need to increase the fertilizer (nutrient) use efficiency and economise the use of high-cost mineral fertilizers by accounting for the surplus effect of the applied fertilizers.

Judicious use of chemical fertilizers in combination with organic manures has increased soil available nutrients. Apart from saving the fertilizer consumption STCR approach helps in improving the soil health by ensuring the balanced fertilizer application (Bhatt *et al*. 2020).

In the targeted yield approach, it is assumed that there is linear relationship between grain yield (economic produce) and nutrient uptake by the crop. Targeted yield concept, thus strikes a balance between "Fertilizing the crop" and "Fertilizing the soil". This approach can be used not only for individual field situations but also as a better approximation for planning the requirement of fertilizers on area basis for a given level of crop production. Fertilizer application and the yield targets chosen can be so manipulated that both high profits from fertilizer investment and maintenance of soil fertility can be achieved (Velayutham 1979). The targeted yield approach has been used to formulate fertilizer recommendations across the country (Puri *et al*. 1993, 1994; Verma and Bhagat 1995; Suri *et al*. 1996; Jha *et al*. 1997).

Considering above point, the present investigation was carried out with the objective to recommend judicious and economic application of fertilizer for brinjal crop for particular growing season and agro-climatic zone using soil test crop response approach.

Material and Methods

Experimental Site

The field experiment was conducted during 2017-2018 at N.E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar to study the response of soil and applied nutrients for balanced fertilization in brinjal. The experimental field is situated at the foot hills of Shivalik range of Himalayas at 29^o N latitude, 79^{o}29' E longitude and an altitude of 243.84 m above the mean sea level. The soil of the experimental site was classified as Aquic Hapludoll (Despande *et al.* 1971). Before the start of experiment, soil sample of experimental site was collected and analyzed for various physicochemical properties and are presented in table 1.

Weather and Climate

Climate of the studied area is humid, sub-tropical with hot and dry summers and cool winters. Monsoon season usually begins from third week of June and extends up to last week of September. Few downpours are generally received during winter season (November to March), of which approximately 70% of it is received during rainy season. The area

Table 1. Physicochemical properties of soil

Property	Value obtained	Method employed
Textural analysis		Bouyoucos (1962)
Sand (%)	54.4	
Silt (%)	33.8	
Clay (%)	11.8	
Textural class	Sandy loam	
pH (1:2.5 soil water suspension)	6.99	Jackson (1973)
Electrical conductivity (dS m^{-1})	0.23	Bower and Wilcox (1965)
Organic carbon (%)	0.79	Walkley and Black (1934)
Available nitrogen (kg N ha^{-1})	147.3	Subbiah and Asija (1956)
Available phosphorus (kg P ha^{-1})	16.9	Olsen *et al.* (1954)
Avalable potassium (kg K ha^{-1})	142.3	Hanway and Heidel (1952)
P fixing capacity (%)	80.1	Waugh and Fits (1996)
K fixing capacity (%)	49.1	Waugh and Fits (1996)
DTPA-Zn (ppm)	1.13	Lindsay and Norwell (1978)
DTPA-Cu (ppm)	1.13	Lindsay and Norwell (1978)
DTPA-Fe (ppm)	50.2	Lindsay and Norwell (1978)
DTPA-Mn (ppm)	13.9	Lindsay and Norwell (1978)
Hot water soluble B (ppm)	1.27	Hatcher and Wilcox (1950)

receives average rainfall of about 1433.4 mm. The weekly average daily maximum temperature turns up to 44 °C during summers and as low as 11 °C during the winter season. Furthermore, weekly average daily minimum temperature during summer remains near 28 °C while during winter it goes as low as 0.3 °C. The maximum temperature during the crop growing season reached up to 39.7 °C during the month of May, while the minimum temperature reached to 11.8 °C during the month of March.

Experimental design and Layout

In order to proceed for the main experiment, an exhaustive crop of oats (*Avena sativa)* was grown in first phase during *rabi* season on 23rd of November 2017 to stabilize fertility gradient in the field and bring heterogeneity in experimental field so as to get the better response of soil and applied nutrients. Fertility gradient was created by keeping the first strip unfertilized (control) and applying 100 kg N, 100 kg P_2O_5 and 100 kg K_2O ha^{-1} in the second strip and 200 kg N, 200 kg P_2O_5 and 200 kg K_2O ha^{-1} in the third strip, respectively. Exhaustive crop of oats (*Avena sativa)* was harvested on 5th and 6th March 2018.

One month prior to transplanting, seedlings of brinjal was sown in nursery. All the cultural operations were followed during the nursery raising. Seedlings were transplanted to main field when they attained a height of about 10-15 cm having 2-3 leaf stage with 75 cm × 60 cm planting distance. In second phase, during spring season 2017-18, the test crop of brinjal was transplanted on 5th of March 2018 as per layout and treatments details with different levels of nutrient (Table 2). The experimental area was divided into 3 equal strips corresponding to those made in the fertility gradient experiment. Each strip was further divided into 24 plots resulting total of 72 (24×3) plots.

Recommended agronomic practices like fertilizer application, irrigation, weeding were followed. The sources of nutrient used were urea for N, which was applied in two split doses, half as basal dose at the time of transplanting and remaining half at 30 days after transplanting; full basal dose for P and K were applied during transplanting in the form of single superphosphate (SSP) and muriate of potash (MOP), respectively. Farmyard manure (FYM) (50% moisture, 0.45% N, 0.27% P_2O_5 and 0.39% of K_2O) was applied as basal prior to transplanting. The brinjal crop was harvested on 14th August 2018.

Soil and Plant Analysis

Soil samples were collected at 0-15 cm depth from 72 plots before transplanting of brinjal and analyzed for alkaline $KMnO_4$-N (Subbiah and Asija

Table 2. Levels of N, P_2O_5, K_2O and FYM used for the experiment on brinjal

Levels	FYM (t ha^{-1})	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})
0	0	0	0	0
1	10	60	30	30
2	20	120	60	60
3	-	180	90	90

1956), Olsen-P (Olsen *et al.* 1954) and ammonium acetate extractable-K (Hanway and Heidel 1952). Plant and fruit samples were also collected at maturity, dried, then processed and analyzed for total N, P and K content. The data obtained from soil and plant analyses were used to calculate the basic data *viz.,* nutrient requirement (NR), per cent contribution from soil (CS), fertilizer (Cf), FYM (Cfym) and fertilizer and FYM (Cf^*).

Basic Data Calculation

With the help of basic data fertilizer prescription equations were developed (Rao and Srivastava 2000) as follows:

Nutrient requirement for production of one quintal of economic produce

$$\text{Nutrient requirement (NR)} = \frac{\text{Nutrient uptake (kg)}}{\text{Fruit yield (q)}}$$

The values were reported as kg of N, P_2O_5 and K_2O required for producing one quintal of brinjal. Nutrient requirements were calculated separately for individual plot and then averages were taken for nutrient in question.

Contribution of nitrogen, phosphorus and potassium from soil (Cs)

Efficiency of soil nutrients was calculated from soil test values of unfertilized plots (control plots).

Per cent contribution of available nutrient from soil (Cs) =

$$\frac{\text{Total uptake of nutrient in control plot}}{\text{Soil test value of that nutrient in control plot}} \times 100$$

Contribution of concerned nutrient from fertilizer without FYM (Cf)

The efficiency of fertilizer was calculated from the plots treated without FYM

Per cent contribution of nutrient from fertilizer (Cf) =

$$\frac{\begin{pmatrix}\text{Total uptake of}\\ \text{nutrients (kg ha}^{-1})\\ \text{in fertilizer and}\\ \text{FYM treated plots}\end{pmatrix} - \begin{pmatrix}\text{Soil test values of}\\ \text{nutrients in fertilizer}\\ \text{and FYM treated}\\ \text{plots} \times \text{CS}/100\end{pmatrix} - \begin{pmatrix}\text{Nutrient added}\\ (\text{kg ha}^{-1}) \times \text{CFYM}/100\\ \text{through FYM}\end{pmatrix}}{\text{Fertilizer dose (N/P/K) applied (kg ha}^{-1})} \times 100$$

Contribution of nitrogen, phosphorus and potassium from FYM (Cfym)

The efficiency of FYM for any nutrient was calculated from those plots treated with FYM (6 plots)

Per cent contribution of nutrient from FYM =

$$\frac{\begin{pmatrix}\text{Total uptake of nutrients}\\ (\text{kg ha}^{-1})\text{ in only organic}\\ \text{manure treated plots}\end{pmatrix} - \begin{pmatrix}\text{Soil test values of}\\ \text{nutrients in organic}\\ \text{plots} \times \text{CS}/100\end{pmatrix}}{\text{Organic manure nutrients dose (N/P/K) applied (kg ha}^{-1})} \times 100$$

Contribution of concerned nutrient from fertilizer with FYM (Cf)*

The fertilizer efficiency of nutrient with FYM was calculated from plots treated with both organic and inorganic sources of nutrient.

Per cent contribution of nutrients from fertilizer with FYM (CF^*) =

$$\frac{\begin{pmatrix}\text{Total uptake of}\\ \text{nutrients (kg ha}^{-1})\\ \text{in fertilizer and}\\ \text{FYM treated plots}\end{pmatrix} - \begin{pmatrix}\text{Soil test values of}\\ \text{nutrients in fertilizer}\\ \text{and FYM treated}\\ \text{plots} \times \text{CS}/100\end{pmatrix}}{\text{Fertilizer dose (N/P/K) applied (kg ha}^{-1})} \times 100$$

Fertilizer requirements for targeted yield

Fertilizer requirements of N, P_2O_5 and K_2O for targeted yields were worked out as follows:

Fertilizer requirement equations for nutrients through use of chemical fertilizer (Without FYM)

$FN = (NR/Cf) \times 100\ T - (Cs/Cf) \times SN$

$FP_2O_5 = (NR/Cf) \times 100\ T - (Cs/Cf) \times 2.29 \times SP$

$FK_2O = (NR/Cf) \times 100\ T - (Cs/Cf) \times 1.21\ SK$

Fertilizer requirement equations for nutrients through conjoint use of chemical fertilizer and FYM (With FYM)

$FN = (NR/Cf^*) \times 100\ T - (CS/Cf^*) \times SN - (Cfym/Cf^*) \times M$

$FP_2O_5 = (NR/Cf^*) \times 100\ T - (CS/Cf^*) \times 2.29 \times SP - (Cfym/Cf^*) \times 2.29 \times M$

$FK_2O = (NR/Cf^*) \times 100\ T - (CS/Cf^*) \times 1.21\ SK - (Cfym/Cf^*) \times 1.21\ M$

where, FN = Fertilizer N (kg N ha^{-1}); FP_2O_5 = Fertilizer P (kg P_2O_5 ha^{-1}); FK_2O = Fertilizer K (kg K_2O ha^{-1}); NR = Nutrient requirement of N, P and K; Cf = Per cent contribution of concerned nutrient from fertilizer without FYM; Cf* = Per cent contribution of concerned nutrient from fertilizer with FYM; CS = Per cent contribution of concerned nutrient from soil; Cfym = Per cent contribution of concerned nutrient from FYM; T = Targeted yield (q ha^{-1}); SN = Soil test value for available N (kg ha^{-1}); SP = Soil test value for available P (kg ha^{-1}); SK = Soil test value for

Table 3. Significance, R^2 and mean of soil test values of whole plots

Dependent variable	P level	R^2	Mean (%)	CV
SN	<0.01**	0.770	152.6	12.9
SP	<0.01**	0.749	17.8	5.08
SK	<0.01**	0.729	154.6	12.5

available K (kg ha^{-1}); and M = Concerned nutrient content in organic.

Statistical Analysis

Fertilizer requirement data and nutrient use efficiency experiments were analyzed by the method of fitting up of simple as well as multiple regression equations and also as per standard design of AICRP on Soil Test Crop Response Correlation Project (Gomez and Gomez 1984). For the statistical analysis of data, Microsoft Excel (Microsoft Corporation, USA) and SPSS window version 16 (SPSS Inc., Chicago, USA) were used.

Results and Discussion

Fertility gradient stabilizing experiment

On the basis of statistical verification of fertility gradient it was clear that there was proper creation of fertility gradient and it was significant with respect to N, P and K levels. These results validate that experimental field was suitable for soil test crop response studies for the next season test crop (Table 3). The findings are closely accorded with those reported by Chatterjee (2008), Pant and Gautam (2012), Gautam and Pant (2013), Kumar (2016) and Arya (2019) in Mollisol of Uttarakhand. The trend in results obtained in yield and soil test value were found in order, strip III > strip II > strip I. From above findings, it can be established that soil fertility gradient was very well stabilized. Strip III showed high fertility status as well as high yield response followed by strip II and strip I.

Test Crop Experiment

Yield Response and Nutrient uptake

Investigation on yield and nutrient uptake studies of brinjal in three different strips supplemented with graded doses of fertilizers indicated that the highest mean yield (201.0 q ha^{-1}) was found in strip III followed by second strip (166.5 q ha^{-1}) and being lowest (155.3 q ha^{-1}) in first strip. Data showed that maximum nutrient uptake (89.1, 23.6 and 43.6 kg ha^{-1} of N, P and K, respectively) was recorded from strip III followed by strip II (77.0, 19.0 and 34.2 kg ha^{-1} of N, P and K, respectively) and lowest in strip I (72.5, 17.0 and 30.6 kg ha^{1} of N, P and K, respectively) (Table 4). Maximum response of brinjal in terms of nutrient uptake and yield in strip III can be explained due to addition of maximum doses of NPK in strip third which has reflected in brinjal due to residual effect. This was due to combined effect *i.e.* residual as well as addition of more nutrients that resulted in augmenting nutrient uptake and yield of brinjal. Agbo *et al.* (2012) suggested that increase in yield and uptake by brinjal was due to the improvement in growth parameters, the higher number and weight of the fruits obtained from the application of nutrient from different organic and inorganic sources. The results from the present exploration established the fact that initial soil fertility and applied nutrients from external sources has facilitated the yield response and nutrient uptake by brinjal. With increase in the levels of nutrients there was increase in the uptake of nutrients due to increase in growth attributing characters (Singh *et al.* 2005).

Soil available nutrients

The present study has highlighted the fact that variation in the fertility gradient was well established,

Table 4. Range and mean of the soil test values, yield and plant uptake under different strips

Particulars	Strip I	Strip II	Strip III
Organic carbon (%)	0.34-1.25 (0.84)	0.44-1.41 (0.88)	0.59-1.57 (1.11)
Alkaline $KMnO_4$-N (kg ha^{-1})	100.3-175.6 (143.2)	112.9-188.2 (144.8)	138.0-200.7 (169.3)
Olsen-P (kg ha^{-1})	15.6-18.6 (17.3)	16.1-19.0 (17.6)	17.1-19.9 (18.4)
NH_4OAc-K (kg ha^{-1})	110.9-175.8 (138.9)	127.7-182.6 (150.9)	129.9-208.3 (174.0)
Fresh yield (q ha^{-1})	70.8-230.8 (155.3)	80.8-264.2 (166.5)	90.8-300.8 (201.0)
Nitrogen uptake (kg ha^{-1})	17.6-126.0 (72.5.)	24.8-139.4 (77.0)	17.7-127.2 (89.1)
Phosphorus uptake (kg ha^{-1})	2.02-27.6 (17.0)	4.79-34.2 (18.9)	5.1-37.8 (23.6)
Potassium uptake (kg ha^{-1})	9.55-45.9 (30.6)	18.4-59.1 (34.2)	17.4-63.0 (43.6)

Table 5. Basic data for calculating fertilizer dose with and without FYM for targeted yield of brinjal

Particulars	Without FYM			With FYM		
	N	P	K	N	P	K
*Nutrient requirement (kg q^{-1})	0.46	0.11	0.28	0.46	0.11	0.28
Contribution of available nutrient from soil (%)	31.1	23.1	13.2	31.1	23.1	13.2
Contribution from applied fertilizer (%)	25.4	22.9	18.8	35.1	33.9	36.7
Nutrients contribution from applied FYM (%)	-	-	-	64.8	89.2	82.1

Table 6. Soil test based fertilizer adjustment equations for targeted yield of brinjal

Fertilizer dose (kg ha^{-1})	Equation with FYM	Equation without FYM
Nitrogen	FN = 1.32 T - 0.88 SN - 1.85 ON	FN = 1.83 T - 1.22 SN
Phosphorus	FP_2O_5 = 0.76 T - 1.56 SP - 6.03 OP	FP_2O_5 = 1.12 T - 2.30 SP
Potassium	FK_2O = 0.95 T - 0.44 SK - 2.71 OK	FK_2O = 1.34 T - 0.85 SK

which can be further validated by the nutrient status in three different strips. The maximum organic carbon (1.11%) was observed in strip III, whereas the lowest (0.84%) was found in strip I. The soil available nutrient status was maximum (169.3, 18.4 and 174.0 kg ha^{-1} of N, P and K, respectively) in strip III, followed by strip II (144.8, 17.6 and 150.9 kg ha^{-1} of N, P and K, respectively), and lowest in strip I (143.2, 17.3 and 139.0 kg ha^{-1} of N, P and K, respectively) (Table 4). Similarly, wide variability in soil available nutrients under different fertility status was observed from the investigation of Singh *et al*. (2020).

Basic parameters to develop fertilizer prescription equations

The basic data required for formulating the fertilizer prescription equations are given in table 5. The nutrient requirement for production of one quintal of brinjal was 0.46 kg for N, 0.11 kg for P_2O_5 and 0.28 kg for K_2O in sandy loam soils of Pantnagar with humid and subtropical climate. The per cent contribution through soil was 31.1, 23.1 and 13.2 of N, P_2O_5 and K_2O, respectively. The contribution of applied fertilizer alone was 25.4, 22.9 and 18.8 per cent of N, P_2O_5 and K_2O, respectively. The per cent contribution of nutrient through fertilizer along with FYM was 35.1, 33.9 and 36.7 for N, P_2O_5 and K_2O, respectively. The applied FYM contributed 64.8 per cent of N, 89.2 per cent of P_2O_5 and 82.1 per cent of K_2O. The data indicated that per cent contribution from soil was more as compared to per cent contribution from fertilizer in case of N and P_2O_5; whereas in case of K_2O, per cent contribution from fertilizer was more than per cent contribution from soil. The above results are closely accorded with the findings of Kirankumar *et al.* (2019) according to which the contribution of nutrients from fertilizer was 63.7% for K_2O, 48.0% for N and 41.9% for P_2O_5. The contribution of nutrient from fertilizer was higher than that from the soil and followed the order of K_2O > N > P_2O_5. The contribution of nutrients from FYM was 25.5, 15.3 and 27.0% for N, K_2O and P_2O_5, respectively. Hedge (1997) reported that nutrient requirement for production of one tonne fresh brinjal was 3.0 to 3.5 kg N, 0.2 to 0.3 kg P_2O_5 and 2.5 to 3 kg K_2O.

Fertilizer Requirement

The fertilizer dose was calculated using fertilizer prescription equation (Table 6) having the range of soil test values and target yield of brinjal without FYM and with 10 t FYM (Table 7). The results indicated that fertilizer doses increased with increase in target yield of brinjal and there was decrease in the fertilizer doses with increase in soil test value. It can be conferred from the study that with the application of FYM along with chemical fertilizer there was increase in the efficiency of fertilizer which led to saving of fertilizer. Without taking into consideration the general recommended dose for brinjal variety Pant Samrat in Uttarakhand is 120:60:60 NPK kg ha^{-1} along with 20-25 t FYM ha^{-1} for an average yield of 200-250 q ha^{-1}. Whereas, the doses calculated by using fertilizer prescription equation for soil test value of 175, 25 and 200 kg ha^{-1} N, K_2O and P_2O_5, respectively along with application of 10 t FYM ha^{-1} for target yield of 200 q ha^{-1} was 68:76:57. The above investigation clearly illustrated that there was net saving of fertilizer as well ensuring the proper application of fertilizer in accordance to soil test values. The findings are in conformity with study of Kirankumar *et al.* (2019). They reported that the

Table 7. Nutrient requirements for different yield targets of brinjal without and with FYM

Soil test values (kg ha^{-1})	Yield targets of brinjal (q ha^{-1}) without FYM			Yield targets of brinjal (q ha^{-1}) with FYM		
	150	200	250	150	200	250
Available N			N requirements (kg ha^{-1})			
125	121	212	304	46	112	178
150	90	182	273	24	90	156
175	60	151	242	2	68	134
200	29	120	212	-	46	112
Available P			P_2O_5 requirements (kg ha^{-1})			
15	133	189	245	53	91	129
20	121	177	233	46	84	121
25	110	166	222	38	76	114
30	98	154	210	30	68	106
Available K			K_2O requirements (kg ha^{-1})			
100	116	183	251	54	101	149
150	74	141	208	32	79	127
200	31	98	165	10	57	105
250	-	56	123	-	36	83

*FYM contains 0.45% N, 0.27% P_2O_5 and 0.39% of K_2O

general recommendation dose for hybrid brinjal in Andhra Pradesh was 200:100:150 kg ha^{-1} of N, K_2O and P_2O_5, respectively along with application of 25 t FYM ha^{-1} for an average yield of 40-50 t ha^{-1}. While the fertilizer doses as per targeted yield model was 171:87:111 kg ha^{-1} along with 25 t FYM ha^{-1} for the yield level of 60 t ha^{-1}. It indicated from the above results that there was a net saving of 72, 40 and 58 kg ha^{-1} of fertilizer N, P_2O_5 and K_2O, respectively. In India, targeted yield equations for brinjal have been developed and formulated in several states such as Chhattisgarh, Bihar and Kerala (Muralidharudu *et al.* 2007, 2011), Karnataka (Basavaraja *et al*. 2012), Odisha (Mishra *et al*. 2012) and Rajasthan (Dey and Das 2014).

Conclusions

From the above study, it can be concluded that fertilizer recommendation based on soil test crop response approach not only helped in efficient utilization of resources but also ensured achieving desired yield target as per economic conditions of farmer for using fertilizer. Integrated use of nutrients helped in improving nutrient use efficiency and ensured the saving of fertilizer. Validation of these equations by follow up trials is needed which may further be used by farmers and soil testing laboratories for the recommendation of fertilizer doses of brinjal.

Acknowledgment

The authors are grateful to Indian Institute of Soil Science, Bhopal for providing financial assistance through AICRP on STCR during the course of investigation.

References

Agbo, C.U., Chukwudi, P.U. and Ogbu A.N. (2012) Effects of rates and frequency of application of organic manure on growth, yield and biochemical composition of *Solanum melongena* L. (*cv.* 'Ngwa local') fruits. *Journal of Animal and Plant Science* **14**, 1952-1960.

Arya. (2019) Optimization of fertilizer doses through STCR approach for cauliflower (*Brassica oleracea* L var. *botrytis*) grown in Mollisols. *Ph.D. Thesis,* submitted to G.B. Pant University of Agriculture and Technology, Pantnagar.

Basavaraja, P.K., Narasimha, R.P., Nethadhani, R., Prakash, C.N. and Veerabhadraiah, S.S. (2012) Fertiliser and manure prescription equations for different crops grown in various districts of Karnataka. In *District Wise Soil Test Based Fertiliser and Manure Recommendations for Balanced Nutrition of Crops* (Muralidharudu, Y., A. Subbarao, K. Sammi Reddy, Eds.), IISS, Bhopal, Madhya Pradesh, India, 85-106.

Bhatt, P., Singh, S., Bhatt, L., Pant, P.K. and Kumar, S. (2020) Evaluation of fertilizer doses for kharif brinjal (*Solanum melongena* L.) through soil test crop response approach in Mollisols of Uttarakhand. *Current Journal of Applied Science and Technology* **39,** 8-18.

Bouyoucos, G.J. (1962) Hydrometer method improved for making particle size analyses of soils. *Agronomy Journal* **54**, 464-465.

Bower, C.A. and Wilcox, L.A. (1965) *Method of Soil Analysis*. Part 2, ASA, Inc. Madison, Wisconsin, USA.

Bray, R.H. (1954) A nutrient mobility concept of soil plant relationships. *Soil Science* **78**, 9-2.

Cate, R.B. Jr. and L.A. Nelson (1965) A rapid method for correlation of soil test analysis with plant response data. North Carolina Agricultural Experiment Station, International Soil Testing Series. Bulletin No. 1.

Chatterjee, D. (2008) Computation of fertiliser requirement based on INM and yield target for potato (*Solanum tuberosum* L.) and it's residual effect on green gram (*Vigna radiata* L.). *M.Sc. Thesis,* submitted to G.B. Pant University of Agriculture and Technology, Pantnagar.

Choudhary, B. (1976) *Vegetable*. Fourth Edition, National Book Trust of India, New Delhi, pp. 50-58.

Despande, S.B., Ferenbacher, J.B., Beavers, A.H. and Ray, B.W. (1971) Mollisols of tarai region of Uttar Pradesh, Northern India. II Genesis and classification. *Geoderma* **6**, 195-201.

Dey, P. and Das, D.K. (2014) Progress report of the All India Coordinated Project for Investigations on Soil Test Crop Response, IISS, Bhopal.

FAO, IFAD, WFP (2015) The state of food insecurity in the World 2015. In *Proceedings of Meeting the 2015 International Hunger Targets: Taking Stock of Uneven Progress*. Food and Agriculture Organization of the United Nations (FAO), Rome.

Fertiliser and Agriculture Statistics Northern Region (2017-18), pp. 1-5.

Gautam, P. and Pant, P.K. (2013) Integrated fertilizer recommendations for lentil through targeted yield model on Mollisol. *Madras Agricultural Journal* **100**, 372-376.

Gomez, K.A. and Gomez, A.A. (1984) *Statistical Procedures for Agricultural Research*. Second Edition, John Wiley and Sons, New York, 680p.

Hanway, J.J. and Heidel, H. (1952) Soil analysis methods as used in Iowa State College soil testing laboratory. *Iowa State College of Agriculture Bulletin* **57**, 1-31.

Hatcher, J.T. and Wilcox, L.V. (1950) Colorimetric determination of boron using carmine. *Analytical Chemistry* **22**, 567–569.

Hedge, D.M. (1997) Integrated use of inorganic and organic fertilizer in rice-rice cropping system. *Tropical Agriculture* 74, 90-95.

Jackson, M.L. (1973) *Soil Chemical Analysis*. Prentice Hall of India (Pvt.) Ltd., New Delhi.

Jha. S., Suri, V.K. and Verma, T.S. (1996) Response of rainfed maize to integrated nutrient management based on target yield concept in Typic Hapludalf. *Journal of the Indian Society of Soil Science* **45**, 603-605.

Kirankumar, C.H., Santhi, R., Srihari, D. and Maragatham, S. (2019) Soil test crop response studies under integrated plant nutrition system for brinjal on Inceptisol of Andhra Pradesh. *International Journal of Chemical Studies* **7**, 3156-3162.

Kumar, S. (2016) Soil test crop response studies for balanced fertilization of turmeric (*Curcuma longa* L.) in a Mollisol of Uttarakhand. *Ph.D. Thesis,* submitted to G. B. Pant University of Agriculture and Technology, Pantnagar.

Lindsay, W.L. and Norvell, W.A. (1978) Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal* **42**, 421-428.

Mishra, V.N., Srivastava, L.K., Samadhiya, V.K., Patil, S.K. and Sengar, S.S. (2012) Fertiliser and manure prescription equations for different crops grown in various districts of Chhattisgarh. In *District wise soil test based fertiliser and manure recommendations for balanced nutrition of crops*. (Y. Muralidharudu, A. Subba Rao and K. Sammi Reddy, Eds.), IISS, Bhopal, Madhya Pradesh, India, pp. 107-141.

Muhr, G.R., Datta, N.P., Subramoney, H., Leley, V.K. and Donature, R.L. (1965) Soil testing in India USDA, New Delhi.

Muralidharudu, Y., Rathore, A. and Subba Rao, A. (2007) In 18th Progress Report of All India Coordinated Project for investigation on Soil Test Crop Response Correlation. *Journal of the Indian Society of Soil Science*. 1-215.

Muralidharudu, Y., Reddy, S.K. and Subbarao, A. (2011) Farmer's resource based site specific integrated nutrient management and online fertiliser recommendations using GPS and GIS tools. IISS, Bhopal, 1-215.

National Horticulture Production Database (2012-13) Ministry of food processing industries. http://shm.uk.gov.in.

Ng, M., Fleming, T., Robinson, M., Thomson, B. and Graetz, N. (2014) Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: A systematic analysis for the Global burden of disease study 2013. *Lancet* 384, 766-781.

Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, L.A. (1954) Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *United States Department of Agriculture Circular* No. 939.

Pant, P.K. and Gautam, P. (2012) Computation of fertilizer doses by using soil test values for scented rice grown on Mollisol under integrated nutrient management system. *Journal of Soils and Crops* **21**, 28-33.

Puri, G. and Jaipurkar, S.A. (1993) Predication and optimization of soil test based fertilizer recommendation for safflower production in Vertisols of central India. In *Third International Safflower Conference*, held on June 14-18 at Institute of Botany at Beijing, China, pp. 45-51.

Puri, G. and Jaipurkar, S.A. (1994) Evaluating the effects of soil fertility variables on the yield of mustard (*Branica compestris*) on swell shrink soil (Vertisol) of central India accepted for presentation. In *15th International Congress of Soil Science*, pp. 45-49.

Ramamoorthy, B. Velayutham, M. and Mahajan. V.K. (1974) Recent trends in making fertilizer recommendation based on soil test under fertilizer resource constraints in India. In *Proceedings FAI/FAO National Seminar*, New Delhi, pp. 335-346.

Ramamoorthy, B., Narasimhan, R.L. and Dinesh, R.S. (1967) Fertilizer application for specified yield targets of Sonora 64 (wheat). *Indian Farming* **17**, 43–45.

Rao, S. and Srivastava, S. (2000) Soil test based fertilizer use a must for sustainable agriculture. *Fertiliser News* **45**, 25-38.

Singh, R.K., Singh, J., De, N. and Rai, M. (2005) Integrated nutrient management influences yield and nodulation of pea. *Vegetable Science* **32**, 59-61.

Singh, V.K., Gautam, P., Singh, S., Pareek, N. and Singh. V.P. (2020) Evaluation of soil fertility gradient experiment on the basis of crop yield, nutrient uptake and soil fertility. *International Journal of Current Microbiology and Applied Sciences* **9**, 2435-2440.

Subbiah, B.V. and Asija, G.L. (1956) A rapid procedure for the estimation of available nitrogen in soils. *Current Science* **25**, 259-260.

Suri, V.K. and Jha, S. (1996) Complementary use of FYM in rainfed maize based on yield target concept. *Annals of Agricultural and Biological Research* **1**, 1-10.

Troug, E. (1960) Fifty years of soil testing. Trans. Transactions of 7th International Congress of Soil Science. Vol. III., Commission IV, Paper No. 7, pp. 46–53.

Velayutham, M. (1979) Fertilizer recommendation based on targeted yield concept problem and prospects. *Fertiliser News* **24**, 12-17.

Verma, T.S. and Bhagat, R.H. (1995) Nitrogen use efficiency as affected by time variant nitrogen application to wetland rice. *Oryza* **32**, 276-279.

Walkley, A. and Black, I.A. (1934) An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Science* **37**, 29-38.

Waugh, D.L. and Fitts, J.W. (1966) Soil test interpretation studies: laboratory and potted plant. *Technical Bulletin, North Carolina State Agriculture Experimental Station (ISTP Series)* No. 3.

WHO (2016) Database on anaemia, vitamin and mineral nutrition information system (VMNIS). World Health Organization, Geneva. https://www.who.int/vmnis/en/

Received 18 August 2020; Accepted 23 June 2021