QUANTITATIVE ESTIMATION OF FERTILIZER REQUIREMENT FOR CHICKPEA IN THE ALLUVIAL SOIL OF THE INDO-GANGETIC PLAINS

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INTRODUCTION

Chickpea is commonly known as gram or bengal gram. This is the most important pulse crop in India. Chickpea is grown by 22 states and 02 union territories of Dadar and Nagar Haveli and Delhi. Chickpea occupies about 35 per cent of area under pulses and contributes about 50 per cent of the total pulse production of India especially in Uttar Pradesh after Madhya Pradesh and Rajasthan. The area and production of chickpea in Uttar Pradesh are 5.05 lakh hectare and 3.78 lakh tonnes respectively. Chickpea productivity in Uttar Pradesh region is about 748.51 kg ha⁻¹. About 38% of the total production of country is from Uttar Pradesh and maximum in Kanpur district (Agriculture and Cooperation Report, Ministry of Agriculture, Government of India 2011-12).

Integrated nutrient management strategies that include site-specific knowledge of crop nutrient requirements, soil nutrient supply, and recovery efficiency of applied fertilizer, are required to sustain high yields and maintain or build up soil fertility at a level that ensures maximum efficiency from nutrient inputs (Singh et al., 2014 and Kumar et al., 2014). Several approaches have been used for fertilizer recommendation based on chemical soil test so as to attain maximum yield per unit of fertilizer use. Among the various approaches, the target yield approach (Ramamoorthy et al., 1967) has found popularity in India (Subba Rao and Srivastava, 2000). This method not only estimates soil test based fertilizer dose but also the level of yield the farmer can achieve with that particular dose. The basic data required for formulating fertilizer recommendation using this approach are nutrient requirement for a unit grain yield, nutrient contribution from soil i.e., nutrient supplying capacity of soil and the nutrient contribution from fertilizer i.e., recovery efficiency of fertilizer nutrient. Quantitative fertilizer requirements based on this approach have been estimated for specific yield target of crops like rice and wheat (Ahmed et al., 2002 and Subba Rao and Srivastava, 2000). FYM is a better source of plant nutrients (Nayak et al., 2014). It has potential in modifying the soil physical properties and improving crop yields and has become an important part of integrated nutrient supply system in developing countries. Recommendations based on Soil Test Crop Response Correlation concept are more quantitative, precise and meaningful because combined use of soil and plant analysis is involved in it. It gives a real balance between applied nutrients and the available nutrients already present in the soil. Keeping the above facts in view and non availability of quantitative study of fertilizers requirements based on target yield for chickpea in Indo-Gangetic plains of Uttar Pradesh this study was conducted.

MATERIALS AND METHODS

A field experiment was conducted on chickpea (var. Pusa - 364) with integrated use of FYM and fertilizer to estimate the fertilizer requirement for specific yield targets of chickpea at the Agriculture Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi and Uttar Pradesh, India. The chickpea grain and straw yield was significantly increased with the soil test values and fertilizer doses of N, P and K. Based on the experiment the nutrient requirement for producing one quintal of chickpea grain was 6.26 kg of N, 1.12 kg of P₂O₅ and 3.78 kg of K₂O. The percent contribution from soil was 25.41, 40.99 and 19.67, respectively. The contribution of fertilizer towards crop response was 117.03, 35.42 and 45.47 % for N, P and K, respectively and the contribution of FYM towards crop response was 11.43, 5.43 and 10.06 % for N, P and K, respectively. Making use of these basic parameters, fertilizer prescription equations were developed for chickpea (var.) Pusa - 364 and a quantitative estimation of fertilizer doses formulated for a range of soil test values and desired yield targets under NPK alone and with FYM.

KEYWORDS

Chickpea
Quantitative estimation of nutrient requirement
Yield target and Fertilizer recommendation

ABSTRACT

A field experiment was conducted in chickpea with integrated use of FYM and fertilizer to estimate the fertilizer requirement for specific yield targets of chickpea at the Agriculture Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi and Uttar Pradesh, India. The chickpea grain and straw yield was significantly increased with the soil test values and fertilizer doses of N, P and K. Based on the experiment the nutrient requirement for producing one quintal of chickpea grain was 6.26 kg of N, 1.12 kg of P₂O₅ and 3.78 kg of K₂O. The percent contribution from soil was 25.41, 40.99 and 19.67, respectively. The contribution of fertilizer towards crop response was 117.03, 35.42 and 45.47 % for N, P and K, respectively and the contribution of FYM towards crop response was 11.43, 5.43 and 10.06 % for N, P and K, respectively. Making use of these basic parameters, fertilizer prescription equations were developed for chickpea (var.) Pusa - 364 and a quantitative estimation of fertilizer doses formulated for a range of soil test values and desired yield targets under NPK alone and with FYM.

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FYM containing, on fresh weight basis, 239, 6, 3, 4 and 700 g of N, P, K, C and organic carbon respectively, was incorporated into the soil 2 weeks before sowing of chickpea. The alluvial soil of the experimental site was sandy loam in texture, with pH (1:2 soil: water) 8.3, electrical conductivity 0.48 dS m⁻¹, CEC 7.3 cmol (p+) kg⁻¹ and organic carbon %, KMnO₄ extractable N, Olsen P and ammonium acetate extractable K contents 0.56, 0.25, 0.025 and 0.21 g kg⁻¹ respectively. Field experiment was conducted with chickpea grown with integrated use of FYM and fertilizers in plots of 4 m long and 3 m wide. The various levels of FYM and fertilizers are used. FYM containing, on fresh weight basis, 239, 6, 3, 4 and 700 g of N, P, K and dry matter, respectively, was incorporated into the soil 2 weeks before sowing of chickpea. Field experiment was conducted with chickpea grown with integrated use of FYM and fertilizers in plots of 4 m long and 3 m wide. The various levels of FYM and fertilizers are used. FYM containing, on fresh weight basis, 239, 6, 3, 4 and 700 g of N, P, K and dry matter, respectively, was incorporated into the soil 2 weeks before sowing of chickpea. Soil test values (STV) of the nutrient in organic plot (%CFYM) = STV/CS/100.

Uptake of nutrient (kg ha⁻¹) in fertilizer treated plot
Percent contribution of nutrients from organic manure (% CFYM)

PERCENT CONTRIBUTION OF NUTRIENTS FROM ORGANIC MANURE

Soil test values of nutrient in fertilizer treated plot × %CS/100

Fertilizer dose (N/P/K) applied (kg ha⁻¹)

N Total uptake of nutrient (kg ha⁻¹) in organic manure treated plot

Soil test values of nutrient in organic plot × %CS/100

Dose (N/P/K) applied (kg ha⁻¹) from organic manure

RESULTS AND DISCUSSION

The data on soil test values of N, P and K; doses of fertilizer N, P, O, and K; nutrient uptake were statistically analyzed. The significant soil test crop response correlations were obtained. The multiple regression equation developed was as under.

Y = b₀ + b₁ SN + b₂ SP + b₃ SP² + b₄ SK + b₅ SK² + b₆ FN + b₇ FN² + b₈ FP + b₉ FP² + b₁₀ FK + b₁₁ FK² + b₁₂ FNSN + b₁₃ FSP + b₁₄ FSK

Where, Y = crop yield (kg ha⁻¹); A = intercept (Kg ha⁻¹); b₀ = regression coefficient; b₁ - b₁₂ = coefficients of the equation.

The area receives an annual rainfall of 1130 mm, about 80% of which occurs from June to September. The mean maximum and minimum temperatures from November to April (chickpea season) are 36.3 and 6.8ºC, respectively. The climate of the region is subtropical, semi arid.
Singh with those reported by Reger and Singh (2014), Singh and al. Contribution from organic matter was low (11.43% N, 5.43% K). These findings are in close conformity with those reported by Reger and Singh (2014), Singh and Singh et al. (2014) and Singh et al. (2014). Higher efficiency of fertilizer nitrogen may be due to atmospheric nitrogen fixation by chickpea crop through symbiotic relationship results indicate that nutrient contribution from fertilizer source are more than from the soil source which is in close conformity with the result responses by Reddy et al. 1994. By using these basic parameters, targeted yield equation for chickpea crop was developed with respect to fertilizer nitrogen, phosphorus and potassium requirement (kg ha⁻¹). The equations are as follows:

**NPK alone**

- F.N. = 5.35 T - 0.22 STV N
- F.P. = 3.71 T - 1.16 STV P
- F.K = 8.32 T - 0.43 STV K

**NPK + FYM**

- F.N. = 5.35 T - 0.22 STV N - 0.098 FYM
- F.P. = 3.71 T - 1.16 STV P - 0.15 FYM
- F.K = 8.32 T - 0.43 STV K - 0.022 FYM

**F.N. = Fertilizer Nitrogen (kg ha⁻¹), F.P. = Fertilizer Phosphorus (kg ha⁻¹), F.K = Fertilizer Potassium (kg ha⁻¹), T = Yield target (q ha⁻¹)**

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

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Strip I</th>
<th>Strip II</th>
<th>Strip III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain yield (q ha⁻¹)</td>
<td>7.12 - 13.02</td>
<td>11.76 ± 0.285</td>
<td>8.72 - 14.62</td>
</tr>
<tr>
<td>Alk. KMnO₄ N (kg ha⁻¹)</td>
<td>208.53 - 249.07</td>
<td>231.80 ± 0.237</td>
<td>222.07 - 260.79</td>
</tr>
<tr>
<td>Olsen's-P (kg ha⁻¹)</td>
<td>19.89 - 25.22</td>
<td>22.61 ± 0.30</td>
<td>21.35 - 27.35</td>
</tr>
<tr>
<td>Ammon. Ac-K (kg ha⁻¹)</td>
<td>178.16 - 215.12</td>
<td>197.21 ± 2.01</td>
<td>189.72 - 233.65</td>
</tr>
</tbody>
</table>

Table 2: Basic data for calculating fertilizer doses with FYM for targeted yields of Chickpea

<table>
<thead>
<tr>
<th>Particulars</th>
<th>With farm yard manure</th>
<th>Without farm yard manure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrient requirement (kg) to produce one quintal of barley grain.</td>
<td>6.26</td>
<td>3.78</td>
</tr>
<tr>
<td>Percent contribution from soil as its available nutrients (CS)*</td>
<td>25.41</td>
<td>40.99</td>
</tr>
<tr>
<td>Percent contribution from applied fertilizer nutrients with FYM(CF)</td>
<td>117.03</td>
<td>35.42</td>
</tr>
<tr>
<td>Percent contribution from applied FYM nutrients (CFYM)</td>
<td>11.43</td>
<td>5.43</td>
</tr>
</tbody>
</table>

Table 3: Estimation of soil test based fertilizer recommendation for 16 q ha⁻¹ grain yield target of chickpea crop

<table>
<thead>
<tr>
<th>Soil test values (kg ha⁻¹)</th>
<th>Fertilizer doses (kg ha⁻¹) under NPK alone</th>
<th>Fertilizer dose (kg ha⁻¹) under NPK + FYM</th>
</tr>
</thead>
<tbody>
<tr>
<td>SN, SP, SK</td>
<td>FN, FP, K</td>
<td>FN, FP, K</td>
</tr>
</tbody>
</table>

Table 4: Prediction equations for post-harvest soil test value for rabi chickpea

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>R²</th>
<th>Multiple regression equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>0.65**</td>
<td>PHN = 152.04 + 0.2477SN** - 0.1302FN** + 12.3298RY**</td>
</tr>
<tr>
<td>P</td>
<td>0.61**</td>
<td>PHP = 9.37 + 0.2212SP** - 0.0467FP** + 0.8889RY*</td>
</tr>
<tr>
<td>K</td>
<td>0.70**</td>
<td>PHK = 7.256 + 0.3857SK** - 0.0164FK + 4.789RY**</td>
</tr>
</tbody>
</table>

*SN, SP, SK, soil available nitrogen, phosphorus (P<sub>2</sub>O<sub>5</sub>) and potassium (K<sub>2</sub>O) (kg ha⁻¹); FYM, FP and FK, fertilizer nitrogen, phosphorus and potassium (K<sub>2</sub>O) required (kg ha⁻¹); RY is relative yield (kg ha⁻¹); **significant at 1% level.

Uttarakhand which is based on same study.

Range and mean of chickpea grain yield under different strips are given in table 1. Maximum yield was obtained in strip III followed by strip II and lowest in strip I. Basic data to calculate the nutrient requirement for targeted yield of chickpea are given in table 2. Nutrient requirement per quintal of chickpea production were observed to be 6.26, 1.12 and 3.78 kg N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O, respectively. Contribution of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O was quantitatively estimated from soil and fertilizer sources was 25.41%, 40.99%, 19.67% and 117.03%, 35.42%, 45.47% respectively. While the percent contribution of nutrient from applied farm yard manure for nitrogen, phosphorus and potassium was 11.43%, 5.43% and 10.06% respectively. These results indicated that nutrient contribution from fertilizer was greater than soil source. The findings are in close conformity with those reported by Reger and Singh (2014), Singh and Singh et al. (2014). Higher value of fertilizer P contribution was probably due to the primary effect. Contribution from organic matter was low (11.43% N, 5.43% P<sub>2</sub>O<sub>5</sub> and 10.06% K<sub>2</sub>O). These findings are in close conformity with those reported by Reger and Singh (2014), Singh and Singh et al. (2014) and Singh et al. (2014). Higher efficiency of

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STV = Soil test values (kg ha\(^{-1}\)) and FYM = Farm Yard Manure (N, P and K content %)

Soil test based fertilizer doses required for the chickpea grain yield target of 16 q ha\(^{-1}\) for varying soil test values of N, P and K are reported in table 3. A perusal of the data indicated that the dose of fertilizer nutrients decreased for each nutrient increase in soil test values. This is the main advantageous component in the soil test based fertilizer application employing targeted yield equations over other approaches of the fertilizer recommendations in which soils are categorized into low, medium and high categories and accordingly the doses of fertilizer nutrients are recommended. Jakhar et al. (2005) also reported that nitrogen application had significant effect up to 125 kg ha\(^{-1}\) for grain and straw yield.

Using a soil test based approach to nutrient management requires index measurement related to crop yield or the effective nutrient supply during the growth period, regular monitoring of soil test values and well developed service infrastructure (Doberman et al. 2003) which is not possible for farmers. So it has become necessary to predict the soil test values after the harvest of a crop. It is done by post harvest soil test values predicting equations making use of the vital soil test values, applied fertilizer doses and the obtained nutrients uptake. The functional relationship is as follows:

\[ Y_p = a + b_1x + b_2xI + b_3xY \]

Where \( Y_p \) is the post harvest soil test value, \( F \) is the applied nutrient fertilizer and \( IS \) is the initial soil test value, \( a \) is an absolute constant and \( b_1, b_2, b_3 \) are the respective regression coefficients.

The predicting equations are significant for the major nutrient viz. N, P, O, and K in the study area. The soil test values generated through this predicting equation may be utilized for soil test based fertilizer recommendation for the next crop in crop rotation. Growing of summer green gram, which fixed atmospheric N, was another reason of fertility improvement of the soil (Tyagi et al., 2014).

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**REFERENCES**


