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

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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 P_2O_5 and 3.78 kg of K_2O. 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.

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 Utter Pradesh after Madhya Pradesh and Rajsthan. The area and production of chickpea in Uttar Pradesh are 5.05 lakh hectare and 3.78 lakh tonnes respectively. Chickpea productivity in Utter 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) in a typic Haplustept at Agriculture Research Farm, in Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India, during the year 2013-2014. The site is located in the Indo-Gangetic alluvial tract at 25º18' N and 80º36' E, at an altitude of 80.71 m above mean sea level (amsl). The climate of the region is subtropical, semi arid. 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 alluvial soil of 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 %, $KMnO_4$ 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 kg^{-1} C, N, P, K and dry matter, respectively, was incorporated into the soil 2 weeks before sowing of chickpea. Fertilizer used was urea, single super phosphate and muriate of potash. Full dose 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 from the 0-15 cm soil layer in 3 locations in each plot were collected using a core sampler. The entire volume of soil was weighed and mixed thoroughly and a subsample was taken to determine dry weight. The fresh soil was air-dried for 7 days, sieved through a 2 mm screen, mixed, and stored in sealed plastic jars for analysis. Representative subsamples were drawn to determine physicochemical properties using standard procedures (Page *et al.* 1982). Available N, P and K status of soil were estimated using the chemical soil test methods (Subbiah and Asija (1956), Olsen *et al.* (1954) and ammonium acetate-K (CSTPA, 1974). Grain and straw samples at harvest were analyzed for total N, P and K as per the standard procedures.

Plot wise soil test data, fertilizers doses, yield and uptake were used for obtaining NR (Nutrient required to produce a ton of chickpea 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.

Nutrient requirement in kg per ton of grain (NR)

$$= \frac{\text{Uptake of the nutrient (kg ha}^{-1})}{\text{Grain yield of the crop (t ha}^{-1})}$$

Percent contribution of nutrients from soil (% CS)

$$\frac{\text{Uptake of nutrient in the control plot (kg ha}^{-1})}{\text{Soil test values (STV) of the nutrient in control plot (kg ha}^{-1})} = \text{X } 100$$

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

$$= \frac{\text{Uptake of nutrient (kg ha}^{-1}\text{) in fertilizer treated plot} - \text{Soil test values (kg ha}^{-1}\text{) of nutrient in fertilizer treated plot} \times \text{\%CS/100}}{\text{Fertilizer dose (N/P/K) applied (kg ha}^{-1})} \times 100$$

Percent contribution of nutrients from organic manure (%CFYM)

$$= \frac{\text{N Total uptake of nutrient (kg ha}^{-1}\text{) in organic manure treated plot} - \text{Soil test values (kg ha}^{-1}\text{) of nutrient in organic plot} \times \text{\%CS/100}}{\text{Dose (N/P/K) applied (kg ha}^{-1}\text{) from organic manure}} \times 100$$

These parameters were used to develop equations for soil test based fertilizer recommendations for desired yield targets of chickpea under NPK alone and with FYM.

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:

$$Y = \pm A \pm b_1SN \pm b_2SN^2 \pm b_3SP \pm b_4 SP^2 \pm b_5 SK \pm b_6 SK^2 \pm b_7FN \pm b_8FN^2 \pm b_9FP \pm b_{10}FP^2 \pm b_{11}FK \pm b_{12}FK^2 \pm b_{13}FNSN \pm b_{14} FPSP \pm b_{15}FKSK$$

Where, Y= crop yield (kg ha^{-1}); A= intercept (Kgha^{-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 data on soil test values of N, P and K; doses of fertilizer N, P_2O_5 and K_2O nutrients; grain yield of chickpea and nutrient uptake were statistically analyzed. The significant soil test crop response correlations were obtained. The multiple regression equation developed was as under.

$$Y = 23.44 - 0.185533\ SN + 0.540870\ SP - 0.0735499\ SK + 0.325414\ FN - 0.008616\ FP + 0.055894\ FK + 0.000\ 4910\ SN^2 - 0.008845\ SP^2 + 0.0002629 SK^2 + 0.0001800\ FN^2 - 0.000534\ FP^2 - 0.001373\ FK^2 - 0.002127\ SNFN + 0.0019406\ SPFP + 0.0000523\ SKFK$$

R^2 = 0.8853 (Alkaline $KMnO_4$-N, Olson's p and Ammonium Acetate -K)

From R^2 value, it can be observed that variation up to 88.53 % in chickpea grain yield can be explained by the variation in soil test values and fertilizer dose. The response of N, P and K fertilizer application were significant for grain yield of chickpea and followed law of diminishing returns. Singh *et al.* (2005) also find similar results on maize and chickpea by doing quantitative estimation of fertilizers requirements in the Alluvial Soil of the Indo-Gangetic Plains. Percent organic carbon and alkaline $KMnO_4$ nitrogen were found to be usually high and good indices for N availability in chickpea grown area in most of the Indian soils (Coordinators Report, STCR, 1985–93). Gautam *et al.* (2013) also reported that STCR for optimizing integrated plant nutrient supply of pea in Mollisols of

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

Particulars	Strip I Range	mean	Strip II Range	mean	Strip III Range	mean
Grain yield (q ha^{-1})	7.12- 13.02	11.76±0.285	8.72-14.62	13.36±0.282	9.52-15.97	14.49±0.283
Alk. $KMnO_4$ N (kg ha^{-1})	208.53-249.07	231.80±2.27	222.07-260.79	246.14±2.03	242.53-269.34	259.00±1.42
Olsen;s-P (kgha^{-1})	19.89-25.22	22.61±0.30	21.35-27.35	24.26±0.33	24.35-33.75	29.41±0.52
Ammo. Ac-K (kg ha^{-1})	178.16-215.12	197.21±2.01	189.72-233.65	219.06±2.32	208.09-236.93	223.84±2.96

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

Particulars	With farm yard manure			Without farm yard manure		
	N	P	K	N	P	K
Nutrient requirement (kg) to produce one quintal of barley grain.	6.26	1.12	3.78	6.26	1.12	3.78
Percent contribution from soil as its available nutrients (CS)*	25.41	40.99	19.67	25.41	40.99	19.67
Percent contribution from applied fertilizer nutrients with FYM(CF)	117.03	35.42	45.47	117.03	35.42	45.47
Percent contribution from applied FYM nutrients (CFYM)	11.43	5.43	10.06			

*Soil tests values at (0-15cm depth) Alkaline $KMnO_4$-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 16 q ha^{-1} grain yield target of chickpea crop

Soil test values (kg ha^{-1})			Fertilizer doses (kg ha^{-1}) under NPK alone			Fertilizer dose (kg ha^{-1}) under NPK+ FYM		
SN	SP	SK	FN	FP_2O_5	FK_2O	FN	FP_2O_5	FK_2O
140	10	120	55.24	47.79	81.1	49.36	34.58	72.26
160	15	140	50.9	42.01	72.44	45.02	28.79	63.6
180	20	160	46.56	36.22	63.78	40.68	23.01	54.94
200	25	180	42.22	30.44	55.12	36.34	17.22	46.28
220	30	200	37.88	24.65	46.46	32	11.44	37.62

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

Nutrients	R^2	Multiple regression equation
N	0.65**	PHN=152.04 +0.2477SN** -0.1302FN* +12.3298RY**
P	0.61**	PHP=9.37 +0.2212SP** -0.0467FP**+0.8889RY*
K	0.70**	PHK=72.56 +0.3857SK**-0.01646FK +4.789RY**

SN, SP, SK; soil available nitrogen, phosphorus (P_2O_5) and potassium (K_2O) (kg ha^{-1}); FN, FP and FK; fertilizer nitrogen, phosphorus and potassium (K_2O) required (kg ha^{-1}). RY is relative yield (kg/ha); **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_2O_5 and K_2O, respectively. Contribution of N, P_2O_5 and K_2O 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 closely accorded with those reported by Gautam *et al.* (2013), Bera *et al.* (2006) 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_20_5 and 10.06% K_20). 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 nitrogen from fertilizer 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 - 0.22 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})

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:

$Y_{ph} = a + b_1 x F + b_2 x IS + b_3 x$ Yield/ (uptake of nutrient)

Where Y_{ph} 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 and b_3 are the respective regression coefficients.

The predicting equations are significant for the major nutrient viz. N, P_2O_5 and K_2O 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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