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FERTILIZER RECOMMENDATION BASED ON SOIL TESTING FOR THE TARGETED YIELD OF PEGEONPEA IN *VERTISOLS*

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ABSTRACT
A field experiment was conducted on pigeon pea crop under soil test crop response correlation studies in Junagadh region of Gujarat during *kharif* 2012 and 2013. The nutrients requirement for producing one quintal of pigeon pea seed was 6.09, 1.98 and 1.78 kg of N, P_2O_5 and K_2O respectively. The percent contributions from soil and fertilizer nutrients were found to be 27.22 and 86.88 for nitrogen, 60.59 and 37.65 for phosphorus and 7.46 and 14.10 for potassium, respectively. Similarly, the percent contribution of fertilizers in presence of FYM was 114 for nitrogen, 45.51 for phosphorus and 17.39 for potassium. The percent nutrient contribution of FYM was 15.38 for nitrogen, 4.97 for phosphorus and 5.27 for potassium. As per the IPNS based fertilizer prescription equation, for obtaining 15 q ha^{-1} seed yield of pigeon pea on vertisols considering the average soil test value as 180, 23 and 190 kg ha^{-1} of available N, P and K, respectively the requirement of fertilizer nutrients were 37, 30 and 81 kg ha^{-1} of N, P_2O_5 and K_2O, respectively along with 5 t FYM ha^{-1}.

INTRODUCTION

Fertilizer is one of the costliest inputs in agriculture and the use of right amount of fertilizer is fundamental for farm profitability and environmental protection. To enhance farm profitability under different soil-climate conditions, it is necessary to have information on optimum doses for crops. Traditionally, to determine the optimum fertilizer doses of most appropriate method is to apply fertilizer on the basis of soil test and crop response studies. During 1956-57 the semi-quantitative soil test calibrations were evolved and advocated for the use. Among the various approaches, the targeted yield approach (Troug 1960; Ramamoorthy *et al*., 1967) has been found popularity in India. Subsequently in India the quantitative refinements in the fertilizer recommendations based on the soil and plant analysis were made (1967-68) through the All India Coordinated Research Project for Investigation on Soil test crop response correlation (STCRC). The ICAR project on soil test crop response correlation used the targeted yield approach to develop relationship between crop yields on the one hand and soil test values and fertilizer inputs on the other. Targeted yield concept is based on quantitative idea of the fertilizer needs based on yield and nutritional requirement of the crop, per cent contribution of the soil available nutrient and that of the applied fertilizer (Regar and Singh, 2014). This method not only estimates soil test based fertilizer dose but also the level as yield that farmer can achieve with that particular dose. Application of fertilizers by the farmers in the field without information on crop requirement may cause adverse effects on soils and crops owing to over use or inadequate use. Future, exorbitant cost of fertilizers also dictates a more comprehensive approach for fertilizer utilization incorporating soil tests, field research and economic evaluation of results. Pigeon pea commonly known as red gram or tur or arhar is the fifth predominant legume crop in the world and second in India after chickpea. In India, 30.90 lakh tones of pigeon pea grains are produced from an area of 37.49 lakh hectares with the productivity of 824 kg ha^{-1}. Gujarat occupies an area of 2.65 lakh hectares with production of 2.94 lakh tones with the productivity of 1109 kg ha^{-1}.

The fertilizer application practices based on targeted yield approach indicated the possibility of enhancing production potentials of pigeon pea. The targeted yield approach along with FYM for pigeon pea has not been studied. Hence, the present study was under taken to develop balanced fertilizer schedule with or without FYM application for desired yield targets of pigeon pea on a vertisols.

MATERIALS AND METHODS

A soil test crop response correlation study on pigeon pea (Var. AGT-1) was conducted during 2012-13 on a vertisols at Pulse Research Station, Junagadh Agricultural University, Junagadh. The inductive-cum-fertility gradient approach of Ramamoorthy *et al*. (1967) was followed for conducting the experiment. Three fertility gradients were created by dividing the experimental field into three equal strips which were fertilized with $N_0P_0K_0$, $N_1P_1K_1$ and $N_2P_2K_2$ levels. These fertility

gradients were fertilized as L_0 : no N, P_2O_5 and K_2O, L_1 : 80 - 40 - 40 kg ha^{-1} and L_2 : 160 - 80 - 80 kg ha^{-1}, N, P_2O_5 and K_2O, respectively. Maize as an exhaustive crop was grown so that the fertilizers could undergo transformations in the soil with plant and microbial agencies. By growing the exhaustive crop the operational range of soil fertility was created in the fertility strips which was evaluated in terms of variations in fodder yield, uptake and soil test values. After the harvest of exhaust crop, the main experiment on pigeon pea was conducted. Each strip was divided into 15 equal size plots. Twelve selected fertilizer treatment ($N_{50}P_{50}K_{50}$, $N_{25}P_{25}K_{50}$, $N_{25}P_{50}K_{75}$, $N_0P_{75}K_{50}$, $N_{25}P_{100}K_0$, $N_0P_{50}K_{75}$, $N_{50}P_0K_{75}$, $N_{25}P_{75}K_{100}$, $N_{25}P_{75}K_{75}$, $N_{25}P_{75}K_0$, $N_{25}P_{100}K_{50}$ and $N_{50}P_{75}K_{100}$) comprising different combinations of N (0, 25 and 50 kg ha^{-1}), P_2O_5 (0, 50, 75 and 100 kg ha^{-1}) and K_2O (0, 50, 75 and 100 kg ha^{-1}) were randomly distributed in each strip along with the three control ($N_0P_0K_0$) plots. The FYM levels (0, 5 and 10 t ha^{-1}) were imposed across each fertility gradient strips. The initial soil samples before sowing of pigeon pea were collected and analyzed for $KMnO_4$-N (Subbiah and Asija 1956), Olsen-P (Olsen *et al*., 1954) and neutral normal NH_4OAc-K (Hanway and Heidal 1952). The FYM used in the experiment was analyzed for total nitrogen by H_2SO_4 digestion using macro-Kjeldhal method (A.O.A.C. 1990) while phosphorus and potassium were estimated by digesting 1 g dry FYM sample with 10 ml di-acid mixture (HNO_3 : $HCLO_4$). The plot wise yield of pigeon pea and biomass yield were recorded. Plant samples (pigeon pea seed and stalk) from each plot were analyzed for total N, P and K content (Piper, 1996) and total uptake was computed. Using the data on pigeon pea yield, nutrient uptake, initial soil available nutrients and fertilizer dose applied, the basic parameters viz; nutrient requirement (kg q^{-1}), contribution of nutrients from soil (C_s), contribution of fertilizer nutrients in absence (C_{fa}) and presence (C_{fp}) of FYM, and contribution of nutrients from FYM were estimated as described by Ramamoorthy *et al*. (1967). These parameters were used for the formulation of fertilizer adjustment equation for deriving fertilizer doses and the soil test based fertilizer recommendations were prescribed in the form of ready reckoner for desired yield targets of pigeon pea under NPK as well as with FYM.

RESULTS AND DISCUSSION

Soil Available Nutrients and Pigeon pea Seed Yield

The range and mean values of pigeon pea seed yield, and soil available nutrients of treated and control plots were furnished in table-1. The $KMnO_4$-N ranged from 150 to 221 kg ha^{-1} with a mean of 183 kg ha^{-1}, Olsen-P ranged from 15.6 to 29.4 with mean of 23.2 and NH_4OAc-K ranged from 158 to 223 kg ha^{-1} with a mean 190 kg ha^{-1}. The pigeon pea seed yield in treated plots ranged from 9.37 to16.97 q ha^{-1} and in control plots ranged from 5.99 to13.26 q ha^{-1}. The above results clearly indicate that wide variability existed in the soil test value and pigeon pea seed yield of treated and control plots, which is a pre-requisite for calculating the basic parameters and fertilizer adjustment equations for calibrating the fertilizer doses for specific yield targets.

Basic Parameters

The basic parameters *viz*; the nutrient requirement for producing on quintal of pigeon pea seed (kg q^{-1}), the percent contribution of nutrients from soil (C_s), percent contribution of fertilizer nutrients in absence of FYM (C_{fa}), contribution of fertilizer nutrients in presence of FYM (C_{fp}) and percent contribution from FYM (C_{fym}) have been calculated as described by Reddy *et al*. (1964) and Subba Rao and Shrivastava (1999) and presented in table-2. These basic parameters were used for formulating the fertilizer prescription equation under NPK alone and along with FYM (5 t ha^{-1}).

The nutrient requirements per quintal of pigeon pea seed were computed as 6.09, 1.98 and 1.78 kg N, P_2O_5 and K_2O, respectively. The percent contributions of soil were 27.22, 60.59 and 7.46 for N, P_2O_5 and K_2O, respectively. The percent contribution of fertilizer nutrients in absence and presence of FYM were 86.88 and 113.75 for nitrogen, 37.65 and 45.51 for phosphorus and 14.10 and 17.39 for potassium, respectively. Similarly percent contribution of N, P_2O_5 and K_2O from FYM were 18.27, 6.81 and 6.80, respectively.

The data on Cs and C_{fa} or C_{fp} indicated that nutrient contribution from fertilizer source along with FYM were greater than that of in absence of FYM and from soil. The efficiency of added fertilizer nutrients along with FYM increased considerably, which reflected in higher pigeon pea seed yield than control plots. The contribution of N, P_2O_5 and K_2O were higher when fertilizer nutrients were added along with FYM. The addition of FYM might have played an important role for enhancing microbial population and provide enough carbon which leads to higher availability and thereby higher contribution of available nutrients to plants. The findings are in close conformity with those reported by Tamboli *et al*. (1996); Ray *et al*. (2000); Santhi *et al*. (2002); Balasubramaniam *et al*. (2005); Kadam and Sonar (2006) and Dalal and Nandkar (2010).

Fertilizer Prescription Equation for Desired Yield Targets of

Table1 : Range and mean values of available nutrients in the soil and pigeon pea seed yield

Parameters	Range	Mean
Soil test value (kg ha^{-1})		
$KMnO_4$-N	150-221	183
Olsen-P	15.6-29.4	23.2
NH_4OAc-K	158-223	190
Pigeon pea yield (q ha^{-1})		
Treated plots	9.37-16.97	12.96
Control plots	5.99-13.26	9.14

Table2 : Nutrient requirement, percent contribution from soil, fertilizer and FYM for pigeon pea

Parameter	N	P_2O_5	K_2O
Nutrient requirement (kg q^{-1})	6.09	1.98	1.78
Contribution for soil available nutrients (%) (C_s)	27.22	60.59	7.46
Contribution from fertilizer nutrients in absence of FYM (%) (C_{fa})	86.88	37.65	14.10
Contribution from fertilizer nutrients in presence of FYM (%) (C_{fp})	113.75	45.51	17.39
Contribution nutrients from FYM (%) (C_{fym})	18.27	6.81	6.80

Table3 : Soil test based fertilizer prescription equations for targeted yield of pigeon pea

Without FYM	With FYM (5 t ha^{-1})
FN : 6.81 T - 0.26 SN	FN : 5.46 T - 0.25 SN - 0.16 FYM
FP_2O_5 : 4.99 T - 1.32 SP	FP_2O_5 : 4.11 T - 1.34 SP - 0.15 FYM
FK_2O : 11.94 T - 0.43 SK	FK_2O : 11.93 T - 0.51 SK - 0.45 FYM

Note : FN, FP_2O_5 and FK_2O - Fertilizer N, P_2O_5 and K_2O in kg ha^{-1}, respectively : T - yield target in q ha^{-1}, SN, SP and SK - $KMnO_4$-N, Olsen-P and NH_4OAc-K in kg ha^{-1}, respectively, FYM : t ha^{-1}.

Table4: Soil test based fertilizer recommendations for pigeon pea

Soil test value (kg ha^{-1})	NPK alone			NPK + FYM (5 t ha^{-1})		
	15 q ha^{-1}	20 q ha^{-1}	25 q ha^{-1}	15 q ha^{-1}	20 q ha^{-1}	25 q ha^{-1}
Nitrogen						
150	63	97	131	44	71	99
170	58	92	126	39	66	94
190	53	87	121	34	61	89
210	48	82	116	29	56	84
230	42	76	111	24	52	79
Phosphorus						
10	62	87	112	48	68	89
13	58	83	107	44	64	85
16	54	79	104	40	60	81
19	50	75	100	36	56	77
22	46	71	96	32	52	73
Potash						
225	82	142	201	63	122	182
250	71	131	191	50	109	169
275	61	120	180	37	97	157
300	50	110	169	25	84	144
325	39	99	158	12	72	131

Pigeon pea

Soil test based fertilizer prescription equations for targeted yield of pigeon pea were formulated using the basic parameters (Table-3). On the basis of these equations a ready reckoner was prepared for a range of soil test values and for pigeon pea seed yield targets of 15, 20 and 25 q ha^{-1} (Table-4).

Fertilizer N, P_2O_5 and K_2O requirements decreased with an increase in soil test values. For producing 15 q ha^{-1} of pigeon pea yield on vertisols, the fertilizer dose required for the average soil test value 180, 23 and 190 kg N, P and K, respectively were 55, 45 and 97 kg ha^{-1} of N, P_2O_5 and K_2O, respectively. However in order to produce 20 and 25 q ha^{-1} pigeon pea with above soil test values, the fertilizer requirement would be 89 and 123 kg ha^{-1} N, 69 and 94 kg ha^{-1} P_2O_5, and 157 and 216 kg ha^{-1} K_2O, respectively, without FYM.

Application of FYM @ 5 t ha^{-1} along with soil test based fertilizer recommendation would be able to save 18, 15 and 16 kg ha^{-1} N, P_2O_5 and K_2O, respectively. The application of fertilizer nutrient based on targeted yield approach will be highly economical and viable technology considering soil health and desired yield targets. Similar results were also reported by Santhi *et al*. (2002) for onion on *Inceptisols*, Singh *et al*. (2005) for maze and chickpea in the alluvial soil of Indo-Gangetic plains and Jadhav *et al*. (2013) for garlic in *Inseptisols*.

The foregoing results revealed the targeted yield concept could be effectively adopted to bring in site specificity in fertilizer use and achieve high yields of pigeon pea on the *Vertisols* of Saurashtra region of Gujarat. Also, the fertilizer application rates will be subsequently curtailed with conjoint use of fertilizers and organic manure.

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