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Site Specific nutrient management through targeted yield equations formulated for green gram [*Vigna radiata* (L.) Wilczek]

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ABSTRACT

A field experiment was conducted to formulate the fertilizer prescription equations for achieving desired yield target of green gram [*Vigna radiata* (L.) Wilczek] during 2013-14. Three fertility gradient stripes were created by applying no fertilizer, recommended dose of fertilizer (RDF) and double of the RDF in rice in order to develop three fertility gradient stripes during *kharif*. Each strip was again sub-divided into 24 sub plots and green gram was cultivated with different treatment combinations. One plot was kept as absolute control while FYM was applied in two sub-plots and rest 21 plots were applied with different graded doses of fertilizers. Initial and post harvest soil nutrient status, nutrient uptake, nutrient requirement, soil efficiency, fertilizer efficiency and yield data were recorded. The highest yield (12.15 q ha^{-1}) was achieved with application of 30:50:50 (N: P_2O_5: K_2O). Fertilizer prescription equations were formulated by multiple regression equation for site specific nutrient management on the basis of initial soil fertility status and targeted yield approach. The equations and ready reckoner were developed for higher production with optimum use of fertilizers according to desired yield target of green gram with sustainable manner.

Key words: Fertility gradient, Fertilizer prescription equation, Green gram, Inceptisols, Ready reckoner, Targeted yield

INTRODUCTION

Green gram (*Vigna radiata* L. Wilczek) belongs to *Leguminoseae* family and *Papilionaseae* subfamily. It is one of the important grain-legume crops ranks third among the pulses grown in India after chickpea and pigeon pea. It is extensively cultivated in Southeast Asian countries, Central Africa and Australia (Dahiya *et al.*, 2015). India is the leading green gram cultivator with 55 percent of the total world acreage and 45 percent of total production (Rishi, 2009; Singh and Nagarajan, 2013) mostly grown in intercropping with wheat, maize, potato, etc. during the monsoon season and as a monoculture at other times (Singh *et al*., 2014). Green gram seeds contain approximately 25 to 28 percent protein, 1.0 to 1.5 percent oil, 3.5 to 4.5 percent ash and 62 to 65 percent carbohydrates on dry weight basis (Yadav, *et al.*, 2009). It is an excellent source of protein with high quality of lysine (460 mg g^{-1}), tryptophan (60 mg g^{-1}), ascorbic acid and riboflavin (0.21 mg 100 g^{-1}) (Azadi *et al.*, 2013). People generally consume green gram sprouts due to their rich nutritional value consisting of proteins, dietary fibre and bio-active phyto-compounds (Huang *et al*., 2014). Recent studies have shown that green gram sprouts after germination has more ostensible biological activities and more abundance of secondary metabolites since relevant biosynthetic enzymes are activated during the initial stages of germination (Tang *et al*., 2014). In India, pulses occupy 26.28 million hectares with total production of 18.09 million tonnes with an average productivity of 689 kg ha^{-1} (DE&S, 2012). Stagnated production of pulses is due to low productivity combined with ever increasing population has led to sharp decline in per capita availability from 63 g/day in 1961 to merely 31.6 g in 2010 (DE & S, 2011). The yield of pulse crops is low due to lack of awareness in adoption of improved technology (Kumar, 2014a and Kumar, 2014b). Inclusion of legumes in crop sequence increases the soil fertility and consequently the productivity of succeeding cereal crops (Singh and Shivay, 2013). Integrated nutrient management intended for four major goals viz. to maintain soil productivity, to ensure sustainable productivity, to prevent degradation of the environment and to reduce expenditure on the cost of chemical fertilizers. (Sharma *et al*., 2004).

The concept of fertilizer prescription equation for desired yield target was first given by Troug (1960). Later on Ramamoorthy (1967) established theoretical basis and experimental technique to suit it in Indian condition showing the linear relationship between yield and nutrient uptake. For a given quantity of yield of any crop fertilizer requirement can be estimated considering efficiency of soil and fertilizer nutrients. Fertilizer prescription equations have been developed for field crops like Groundnut (Pradhan *et al*., 2007), Sesamum (Mishra *et al*., 2008), Mustard (Mishra *et al*., 2011) and vegetables like, Lady's finger (Mishra *et al*.,

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2013) and Tomato (Mishra *et al*., 2013) but no such equations have been developed for Green gram for *Inceptisols*. Keeping the above information in view a field investigation was carried out to formulate the targeted yield equations for green gram for integrated nutrient management in various soil fertility statuses in an *Inceptisol* of Odisha.

MATERIALS AND METHODS

The experimental site is characterized by medium land, sandy loam in texture with moderate soil acidity (pH 5.39) and low organic carbon content (3.7 g kg^{-1}). CEC of the surface soil is 4.5 cmol (p^+) $kg^{-1}$with 65.1 percent base saturation. The experimental site is low in available soil N (154.5 kg ha^{-1}), medium in available P (17.3 kg ha^{-1}), low in available K (67.8 kg ha^{-1}) and sufficient in available S (18.2 mg kg^{-1}). The soil was classified as *fine, mixed, hyperthermic* family of *Vertic Haplustepts.*

The experimental site (0.3 ha) was divided into three equal blocks during *kharif* 2013 to create fertility gradient stripes. Rice (cv. *Lalat*) was grown in three fertility gradient stripes viz. without application of N, P, K in Block-I, N_{80} P_{40} K_{40} (recommended dose) in Block-II and N_{160} P_{80} K_{80} (double of the recommended dose) in Block-III; thus, three fertility gradient stripes B-I, B-II and B-III were created. During *rabi* these three blocks were ploughed and each block was divided into 24 subplots (5.5 x 4.0 meter each). Initial soil samples were collected from each plot for initial nutrient status. Available soil N was analyzed by Alkaline Permanganate method, available P_2O_5 by Bray's No-1 method and soil available K_2O by Neutral Normal Ammonium Acetate method as described by Jackson(1973). In each stripe, out of 24 subplots, 21 plots were super imposed with different graded doses of N, P, K; two plots were given FYM at 5 and 10 t ha^{-1} respectively and one plot was kept absolute control. Green gram (cv. *Durga*) was grown during *rabi*. The N levels for green gram were kept 0, 10, 20 and 30; P & K levels were 0, 30, 40 and 50 kg ha^{-1} each (Table 1). Post harvest soil samples, stover and grain samples, yield data were recorded to study the nutrients uptake followed by formulation of fertilizer prescription equations.

Table 1: Combination of treatments with different levels of fertilizers.

T_1- N_0 P_{40} K_{40}	T_{13}- N_2 P_{50} K_{40}
T_2- N_{10} P_{30} K_{30}	T_{14}- N_2 P_{50} K_{40}
T_3- $N_{10}P_{30}K_{40}$	T_{15}- N_{10} P_{50} K_{40}
T_4- N_{10} P_{40} K_{30}	T_{16}-N_{30} P_{40} K_{30}
T_5- N_{10} P_{40} K_{40}	T_{17}- N_{30} P_{40} K_{40}
T_6- N_{20} P_0 K_{40}	T_{18}- N_{30} P_{40} K_{50}
T_7- N_{20} $P_{30}K_{30}$	T_{19}- N_{20} P_{30} K_{50}
T_{8}- N_{20} P_{30} K_{40}	T_{20}- N_{30} P_{50} K_{40}
T_9- N_{20} P_{40} K_0	T_{21}- N_{30} P_{50} K_{50}
T_{10}-N_{20} P_{40} K_{30}	T_{22}- N_0 P_0 K_0 and FYM @5t ha^{-1}
T_{11}-N_{20} P_{40} K_{40}	T_{23}-N_0 P_0 K_0 and FYM @10t ha^{-1}
T_{12}- N_{20} P_{40} K_{40}	T_{24}-N_0 P_0 K_0 (Control)

The required parameters to formulate fertilizer prescription equations for specific yield targets yield were experimentally obtained for a given soil-type-crop-agroclimatic condition. Nutrient requirement (NR), Soil efficiency (Cs) and Fertilizer efficiency (Cf) were found out as the procedure given by Ramamoorthy *et al*. (1967). The available soil nutrient content is taken into consideration while estimating soil efficiency and fertilizer efficiency. Therefore,

$$\text{NR (Nutrient requirement; kg q}^{-1}) = \frac{\text{Uptake of nutrient by Green gram(kg/ha)}}{\text{Hrain yield of Green gram(kg/ha)}}$$

$$\text{Cs (Soil efficiency)} = \frac{\text{Uptake of nutrient in absolute control plot (kg/ha)}}{\text{Initial soil test value of that particular nutrient in control plot(kg/ha)}}$$

$$\text{Cf (Fertilizer efficiency)} = \frac{\text{Uptake of nutrient in fertilizer treated plot (kg/ha)- Initial soil test value (kg/ha) x Cs}}{\text{Amount of fertilizer nutrient applied (kg/ha)}}$$

$$\text{Co (Organic matter efficiency)} = \frac{\text{Total nutrient uptake in organic matter treated plot-Soill test value x Cs}}{\text{Nutrient applied through organic matter}}$$

T – Targeted yield (q ha^{-1}) of Green gram desired to be obtained within its varietal limitation

SN – Initial soil available N (kg ha^{-1}) analyzed by Alkaline permanganate method

SP_2O_5 – Initial soil available P_2O_5 (kg ha^{-1}) analyzed by Bray's No.1 method

K_2O – Initial soil available K_2O (kg ha^{-1}) analyzed by Ammonium acetate method (Subbiah and Asija, 1956)

Co – Efficiency of organic matter.

Soils were analyzed as per the methodologies laid down by Jackson (1973).

These parameters are then transferred to a workable equation as follows:

$$FD = \frac{(NR \times 100 \times T)}{cf} \quad \frac{(Cs \times STV)}{cf} \quad \frac{(Co \times org)}{cf}$$

Where FD = fertilizer dose (kg ha^{-1}); T= yield target (q ha^{-1}) and STV = soil test value.

RESULTS AND DISCUSSION

It was observed that, among three fertility gradient stripes the highest available soil nutrient found in B-III strip as it received double of the recommended doses of fertilizers during *kharif*. The mean value of soil available N, P and K increases with increase in fertility gradient strip from B-I to B-III. Mean available soil N was found 105.0, 119.2 and 125.3 kg ha^{-1}; that of P_2O_5 was found 54.72, 56.14 and 64.38 kg ha^{-1} and mean available K_2O was found 124.3, 134.8 and

162.5 kg ha^{-1} in B-I, B-II and B-III stripes respectively. As B-III strip received the maximum fertilizer (double of the recommended dose in rice) during *kharif* therefore much higher soil fertility status, nutrient uptake and yield were observed. In contrast, the lowest uptake and yield were found in the B-I as no fertilizer was added in rice during *kharif*. Similar observation was recorded by the earlier worker (Mishra *et al*., 2014). The range and average of initial soil test values, uptake of nutrients and grain yield of Green gram are presented in Table 2.

Uptake of N, P, and K shows an increasing trend with increasing fertility gradient strips from B-I to B-III as it was found in case of initial soil nutrients status. The mean uptake of N was found 15.07, 19.1 and 33.1 kg ha^{-1}; that of P_2O_5 was found 10.7, 12.8 and 21.7 kg ha^{-1} and mean K_2O uptake was found 19.7, 22.8 and 34.2 kg ha^{-1} in B-I, B-II and B-III stripes respectively. Similar observation was recorded by Saren *et al*. (2015).

The uptake of nutrients is correlated well with grain yield of Green gram. Result shows that higher the N, P, K uptake higher is the yield of grains. The average yield of grains ranges from 5.7 kg ha^{-1} in the lowest fertility gradient strip (B-I) to 10.6 kg ha^{-1} in the highest fertility gradient strip (B-III) Similar observation was recorded by Pogula *et al*. (2016).

(Where, FN, F P_2O_5 and F K_2O= kg fertilizer N, P_2O_5 and K_2O required; T= specific yield target in (q); S N, S P_2O_5 and S K_2O= kg available soil N, P_2O_5 and K_2O respectively; ON, O P_2O_5 and O K_2O= kg N, P_2O_5 and K_2O added through FYM)

Based on the basic parameters Nutrient requirement (NR) soil efficiency (Cs) and fertilizer efficiency (Cf) calculated as per the procedure given in the materials and methods section and putting them into the workable equations. The fertilizer requirement for targeted yield of

Table 2: Range and average yield of Green gram (*cv. Durga*), soil test values and N, P and K uptake in different fertility gradient stripes**.**

Particulars	**B-I**	**B-II**	**B-III**	
Grain yield (q)	Range	4.61-6.45	5.45-8.13	8.59-12.15
	Average	5.67	6.92	10.62
Available N(kg ha^{-1})	Range	97.3 – 114.2	102.5 – 129.6	114.7 – 132.6
	Average	105.0	119.15	125.25
Available P_2O_5(kg ha^{-1})	Range	35.9 – 59.9	44.06 – 63.8	54.5 – 72.4
	Average	54.72	56.14	64.38
Available K_2O(kg ha^{-1})	Range	120.6- 128.8	114.2 – 140.8	153.8 – 168.9
	Average	124.27	134.76	162.46
N uptake(kg ha^{-1})	Range	7.62-20.92	12.32 – 25.92	21.29-39.68
	Average	15.07	19.05	33.08
P_2O_5 uptake(kg ha^{-1})	Range	7.16-15.11	6.56 – 18.39	12.38-28.72
	Average	10.67	12.83	21.65
K_2O uptake(kg ha^{-1})	Range	12.04-24.43	14.97 – 28.65	23.14-42.36
	Average	19.70	22.80	34.19

Table 3: Fertilizer prescription equations for green gram.

Parameter	**NR(kg q^{-1})**	**Cs(%)**	**Cf(%)**	**Co(%)**	**Fertilizer Prescription Equation**
N	2.83	12.40	23.9	16.7	FN= 11.84 T- 0.51 SN- 0.69 ON
P_2O_5	1.91	16.78	21.8	14.9	F P_2O_5 = 8.76 T-0.76 P_2O_5 -0.68 O P_2O_5
K_2O	3.31	14.07	27.1	13.2	F K_2O = 12.21 T-0.51 S K_2O- 0.48 O K_2O

Table 4: Ready reckoner (without FYM) for fertilizer recommendations for specific yield targets of Green gram (cv. *Durga*) under different soil fertility status.

Available soil nutrient (kg ha^{-1})			**Fertilizer nutrient required (kg ha^{-1})**								
N	**P_2O_5**	**K_2O**	**Targeted yield(8 q ha^{-1})**			**Targeted yield(10 q ha^{-1})**			**Targeted yield(12q ha^{-1})**		
			N	**P_2O_5**	**K_2O**	**N**	**P_2O_5**	**K_2O**	**N**	**P_2O_5**	**K_2O**
100	10	80	44	62	58	67	80	82	92	98	107
120	15	90	34	59	53	57	76	77	82	94	102
140	20	100	23	55	48	47	72	72	71	90	97
160	25	110	13	51	43	37	69	67	61	86	92
180	30	120	5	47	38	27	65	62	51	82	87
200	35	130	5	43	33	16	61	57	41	79	82
220	40	140	5	40	28	6	57	52	31	75	77
240	45	150	5	36	23	5	53	47	20	71	72
260	50	160	5	32	18	5	50	42	10	67	67

Green gram was formulated which is given in Table 3. In the equations, the target (T) has to be fixed by the extension workers, scientists and farmers concerned within its varietal limitation and genetic potentiality and SN, SP_2O_5 and SK_2O values are to be put for available soil nitrogen, phosphorous and potassium which are to be precisely determined in the laboratory by analyzing the soil samples of particular site.

A ready reckoner of fertilizer doses has been prepared taking into consideration of different yield targets at different fertility status in the soils (Table 4) which will be useful for extension officers, scientists and farmers alike in balanced fertilization of crop for targeted yield. When available soil nutrients are higher and/or lower yield targets are fixed then naturally the required fertilizer doses are very less or even negative. In this situation only maintenance dose for particular nutrient is given i.e. 25 percent of the recommended dose (20-40-40) in case of green gram to avoid nutrient mining. These equations will be useful in red, laterite and yellow soils (*Inceptisols and Alfisols*) which constitute 84 percent of the total geographical area of Odisha.

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