Integrated nutrient management and formulation of targeted yield equations for black gram (*Vigna mungo* L.)

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Three fertility gradient stripes were created in Inceptisols of Odisha by applying no fertilizer, recommended dose of fertilizer (RDF) and double the RDF and paddy was grown during *kharif*, 2013. These three stripes were sub-divided into 24 sub-plots and black gram was grown with different graded doses of fertilizers and manure during *rabi*, 2013–14. Initial and post-harvest soil nutrient status, nutrient uptake, nutrient requirement, soil efficiency, fertilizer efficiency and yield data were recorded. The highest yield (12.09 q ha^{-1}) was achieved with 30 : 50 : 50 (N : P_2O_5 : K_2O). On the basis of these data, fertilizer prescription equations were formulated for targeted yield of black gram in Inceptisols of Odisha.

Keywords: Black gram, fertilizer prescription equations, Inceptisols, targeted yield.

BLACK gram (*Vigna mungo* L.) is a tropical leguminous annual herbaceous bean crop which belongs to the Asiatic *Vigna* species along with *V. radiata*, *V. trilobata*, *V. aconitifolia* and *V. glaberecence*[1]. It grows to a height of 30–100 cm with large trifoliate leaves. It is a self-fertilized crop which produces pods of 4–6 cm long and completes its life cycle within three months. Black gram seeds are highly rich in protein (23–26%) and contain many nutrients such as K, P, Ca and vitamins such as vit. A, B_1 and B_3 (ref. 2). Black gram is said to have originated in India where it is most widely grown and considered a highly esteemed grain legume[3]. According to Vavilov[4], it originated from the Indian subcontinent. It is widely cultivated in India, Pakistan and other Asian countries and supplies cheap source of protein[5,6]. Black gram is one of the most important legume crops, and like other pulse crops it has the unique capability to maintain and restore soil fertility through biological nitrogen (N) fixation. Its deep root system also maintains physical properties of soil. However, low productivity in this crop is attributed to its narrow genetic base, poor plant type, vulnerability to abiotic and biotic stresses and cultivation in marginal and harsh environment[7]. In addition, inadequate use of micronutrients is an important factor responsible for lower yield of black gram[8,9]. In modern agriculture production system, chemical fertilizers are an indispensable component for higher production of field crops. About 60% of humanity eventually owes its nutritional survival to N fertilizers. However, the growing concern about the environmental consequences of mineral N use and its future cost perspectives emphasize the need to develop new production technologies that are sustainable both economically and ecologically[10]. In this context, neither do the organic fertilizers fulfill the crop nutrient requirement nor do the chemical fertilizers maintain and restore the physical, chemical and biological health of the soils for sustainable agriculture. Therefore, there is a need for standardizing the mixed use of organic and inorganic sources of nutrition to increase the productivity and improve the soil health[11].

Soil test-based fertilizer recommendation is now highly popular among the farming community. Kanwar[12] has termed soil test as a gimmick unless it gives a correct appraisal of fertility status and predicts fertilizer required for maximum return or definite yield goals. Targeted yield approach is the most appropriate method for balance fertilization. This approach provides the basis for optimum resource utilization and balanced crop nutrient management. Soil test-based fertilizer application is a useful tool and it is presumed that fertilizer prescription equation is a unique technology to optimize need-based fertilizer application. The concept of fertilizer prescription equation for desired yield target was first given by Troug[13]. Later on Ramamoorty[14] established theoretical basis and experimental technique to suit Indian conditions 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. Though fertilizer prescription equations have been developed for field crops like groundnut[15], sesamum[16], rice[17], mustard[18] and vegetables like pumpkin[19], lady's finger[20] and tomato[21], no such equation has been developed for black gram for Inceptisols. The present study was therefore carried out to formulate the fertilizer prescription equations for black gram in various soil fertility status in Inceptisols.

The experimental site was characterized by medium land, sandy loam in texture both in surface and subsurface layers. Soil was moderately acidic (pH 5.39) in reaction and low in organic carbon (3.7 g kg^{-1}). CEC of the surface soil was 4.5 c mol (p$^+$) kg^{-1} with 65.1% base saturation. The experimental site was low in soil available N, medium in available P and low in available K. Soil was classified as fine, mixed, hyperthermic family of Vertic Haplustepts. The chemical properties of a typifying pedon of the experimental site are presented in Table 1.

The experimental site (0.3 ha) was divided into three equal blocks during *kharif* 2012–13 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 the recommended dose) in

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Table 1. Chemical properties of a typifying pedon of the experimental site

Depth (cm)	Organic carbon ($g\ kg^{-1}$)	pH (1 : 2)	EC ($dS\ m^{-1}$)	Exchangeable cations ($Cmol\ (p^+)\ kg^{-1}$ soil) Ca	Mg	Na	K	Sum	Exchange acidity ($Cmol\ (p^+)\ kg^{-1}$ soil)	CEC ($Cmol\ (p^+)\ kg^{-1}$ soil)	Base saturation (%)
0–16	3.7	5.39	0.21	1.78	0.94	0.11	0.10	2.93	1.32	4.50	65.11
16–35	2.9	6.31	0.23	1.70	0.90	0.08	0.10	2.78	1.32	4.28	64.95
35–57	1.8	6.91	0.20	8.78	2.80	0.12	0.42	12.12	2.26	12.48	83.70
57–130	0.9	7.58	0.51	12.14	4.20	0.22	0.97	17.53	2.31	20.10	87.21

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 sub-plots (5.5 × 4.0 m each). Initial soil samples were collected from each plot for initial nutrient status. Available soil N was analysed 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[22]. In each strip, out of 24 sub-plots, 21 plots were superimposed with different graded doses of N, P, K; two plots were given FYM at 5 t and 10 t ha^{-1} respectively and one plot was kept in absolute control. Black gram (cv. Prasad) was grown during *rabi*. The N levels were kept at 10, 20 and 30; P and K levels were 30, 40 and 50 kg ha^{-1} each. Post-harvest soil sample, stover and grain samples, yield data were recorded to study the nutrient uptake followed by formulation of fertilizer prescription equation.

The required parameters for formulating fertilizer prescription equations for targeted yield were experimentally obtained for a given soil type-crop-agroclimatic condition. Nutrient requirement (NR), soil efficiency (Cs) and fertilizer efficiency (Cf) were determined following the procedure reported earlier[14]. The available soil nutrient content is considered while estimating soil efficiency and fertilizer efficiency.

Therefore

NR (nutrient requirement; kg q^{-1}) =

$$\frac{\text{Uptake of nutrient by black gram (kg/ha)}}{\text{Yield of black gram (q/ha)}},$$

Cs (soil efficiency) =

$$\frac{\begin{array}{c}\text{Uptake of nutrient in}\\ \text{absolute control plot (kg/ha)}\end{array}}{\begin{array}{c}\text{Initial soil test value of that}\\ \text{particular nutrient in control plot (kg/ha)}\end{array}},$$

Cf (fertilizer efficiency) =

$$\frac{\begin{array}{c}\text{Uptake of nutrient in fertilizer treated plot}\\ \text{(kg/ha)} - \text{initial soil test value (kg/ha)} \times \text{Cs}\end{array}}{\begin{array}{c}\text{Amount of fertilizer}\\ \text{nutrient applied (kg/ha)}\end{array}},$$

Co (organic matter efficiency) =

$$\frac{\begin{array}{c}\text{Total nutrient uptake in}\\ \text{OM treated plot} - \text{soil test value} \times \text{Cs}\end{array}}{\text{Nutrient applied through OM}},$$

where T is the targeted yield (q ha^{-1}) of black gram desired to be obtained within its varietal limitation; SN, the initial soil available N (kg ha^{-1}) analysed by alkaline permanganate method; SP_2O_5, the initial soil available P_2O_5 (kg ha^{-1}) analysed by Bray's No 1 method; K_2O, initial soil available K_2O (kg ha^{-1}) analysed by ammonium acetate method; Co, the efficiency of organic matter.

Soils were analysed following the methodologies laid down by Jackson[22].

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

$$\text{FD} = \frac{\text{NR} \times 100 \times \text{T}}{\text{Cf}} - \frac{\text{Cs} \times \text{STV}}{\text{Cf}},$$

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

Among the three fertility gradient stripes, maximum available soil nutrient was found in B-III strip as it received double the recommended doses 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 163.40, 180.0 and 190.71 kg ha^{-1}; that of P_2O_5 was 34.62, 44.47 and 53.27 kg ha^{-1} and mean available K_2O was 108.08, 121.55 and 136.71 kg ha^{-1} in B-I, B-II and B-III stripes respectively. As B-III strip received the maximum fertilizer (double the recommended dose in rice) during *kharif*, 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*. The range and average of initial soil test values, uptake of nutrients and grain yield of black gram are presented in Table 2.

Uptake of N, P and K shows an increasing trend with increasing fertility gradient stripes from B-I to B-III as was found in the case of initial soil nutrients status. The mean uptake of N was 14.84, 18.47 and 32.75 kg ha^{-1}; that of P_2O_5 was 10.31, 12.54 and 21.64 kg ha^{-1} and mean

Table 2. Range and average yield of black gram (cv. Prasad), 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	4.63–6.47	5.42–8.02	8.62–12.09
	Average	5.71	6.92	10.67
Available N (kg ha^{-1})	Range	150.8–174.5	170.8–188.5	183.2–197.4
	Average	163.40	180.0	190.71
Available P_2O_5 (kg ha^{-1})	Range	30.4–38.8	39.6–50.5	47.6–57.3
	Average	34.62	44.47	53.27
Available K_2O (kg ha^{-1})	Range	98.3–116.8	112.3–129.3	123.2–148.4
	Average	108.08	121.55	136.71
N uptake (kg ha^{-1})	Range	7.16–20.93	9.10–25.65	21.29–39.64
	Average	14.84	18.47	32.75
P_2O_5 uptake (kg ha^{-1})	Range	7.07–15.02	6.33–18.33	12.40–28.59
	Average	10.31	12.54	21.64
K_2O uptake (kg ha^{-1})	Range	9.19–24.08	12.95–28.77	17.28–39.16
	Average	17.78	21.39	29.89

Table 3. Fertilizer prescription equations developed by AICRP on STCR, Bhubaneswar for black gram

Parameters	NR (kg q^{-1})	Cs (%)	Cf (%)	Co (%)	Fertilizer prescription equations
N	3.50	13.2	25.4	17.3	FN = 14 T – 0.52 SN – 0.68 ON
P_2O_5	1.86	15.4	23.6	12.5	F P_2O_5 = 8.1 T – 0.65 P_2O_5 – 0.52 O P_2O_5
K_2O	2.96	13.1	29.2	13.7	F K_2O = 10.20 T – 0.44 S K_2O – 0.44 O K_2O

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 soil available 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.

Table 4. Ready reckoner for fertilizer recommendations for specific yield targets of black gram (cv. Prasad) under different soil fertility status

Available soil nutrient (kg ha^{-1})			Fertilizer nutrient required (kg ha^{-1})					
			Targeted yield (8 q ha^{-1})			Targeted yield (10 q ha^{-1})		
N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
100	10	80	60	58	46	88	74	67
120	15	90	50	55	42	78	71	62
140	20	100	39	52	38	67	68	58
160	25	110	29	49	33	57	65	54
180	30	120	18	45	29	46	61	49
200	35	130	5	42	24	36	58	45
220	40	140	5	36	20	26	52	40
240	45	150	5	32	16	15	48	36

K_2O uptake was 17.78, 21.39 and 29.89 kg ha^{-1} in B-I, B-II and B-III stripes respectively.

The uptake of nutrient corelates well with grain yield of black gram. Result shows that higher the N, P, K, uptake, higher is the yield of grains. The average yield of grains ranges from 5.71 q ha^{-1} in the lowest fertility gradient strip (B-I) to 10.67 q ha^{-1} in the highest fertility gradient strip (B-III).

Based on basic parameters, nutrient requirement (NR), soil efficiency (Cs) and fertilizer efficiency (Cf) were calculated according to the procedure described above and were put into workable equations. The fertilizer requirement for targeted yield of black gram was formulated (Table 3). In the equations, the target (*T*) has to be fixed by extension scientists/farmers concerned and the SN, SP_2O_5 and SK_2O values have to be put for available soil nitrogen, soil phosphorus and soil potassium of that particular field which has to be precisely determined in the laboratory by analysing the soil samples of that field.

A ready reckoner of fertilizer doses has been prepared considering different yield targets at different fertility status of the soils (Table 4) which will be useful for extension officers, scientists and farmers alike in balanced fertilization of crop for targeted yield. These equations will be useful in red, laterite and yellow soils (Inceptisols and Alfisols) which constitute 84% of the total geographical area of Odisha.

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Ants indicate urbanization pressure in sacred groves of southwest India: A pilot study

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Sacred groves may contain remnants of pristine and primary forests outside the state-owned protected area system. As they are small fragments and located in the neighbourhood of human settlements, towns, and cities, they are likely to be affected by urbanization. We studied the effect of urbanization on the ecosystem health of sacred groves of Kerala using litter-dwelling ants as the indicator taxa. Ants were pitfall-trapped (10–12 traps/sacred grove) from three rural and two urban sacred groves, and identified to species. Overall, 1,119 ants of 32 species and 6 subfamilies (Aenictinae, Dolichoderinae, Ectatomminae, Formicinae, Myrmicinae and Ponerinae) were collected. This corresponds to 76.54% of the estimated

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