Formulation of Targeted Yield Equations for Okra [*Abelmoschus Esculentus* (L.) Monech)] in *Inceptisols* of Odisha

Monali Raut[1], Subhashis Saren[2]

[1]Odisha University of Agriculture and Technology, Bhubaneswar-751003, Odisha, India

[2]Indian Institute of Soil Science, Bhopal- 462 001, Madhya Pradesh, India
[2]Email: saren.soil[at]yahoo.co.in

Abstract: ***A field investigation was carried out to formulate nutrient optimization equations for Okra [Abelmoschus esculentus (L.) Monech] under rice-vegetable cropping system in Inceptisols of Odisha. The investigation was conducted at E-block of the Central Research Farm of Odisha University of Agriculture and Technology located in Bhubaneswar during rabi, 2020-21. It was started with creation of three soil fertility gradient stripes by applying no fertilizer, recommended dose and double of the recommended dose of fertilizer in rice (cv. Lalat) during kharif, 2020. Each fertility gradient strip was sub-divided into 24 sub-plots and super imposed with 21 different combinations of nutrients containing N, P, and K; FYM in two plots at 5t and 10t ha^{-1}and one plot was kept as absolute control and Okra (cv.Kajari) was grown in rabi, 2020-21. The highest yield (223.3 q ha^{-1}) of Okra was achieved in S-III with the application of 130, 70, and 100 kg N, P_2O_5, and K_2O per hectare, respectively. Nutrient requirement (NR) for producing of one quintal of Okra yield was 0.30, 0.12, and 0.20 kg N, P_2O_5 and K_2O. The effect of graded doses of fertilizers on nutrient requirement, yield and nutrient uptake of Okra were studied and subsequently fertilizer prescription equations were derived for targeted yield of Okra. A ready reckoner chart has also been prepared for facilitating farmers to achieve desired yield target of Okra by applying the required quantity of plant nutrients in the existing soil fertility level. The equations provide a basis for site specific nutrient management based on desired yield target under varying soil fertility conditions.***

Keywords: Okra, targeted yield, fertilizer prescription equations, *Inceptisols*, STCR-IPNS

1. Introduction

OKRA [*Abelmoschus esculentus* (L.) Monech] is an annual, dicotyledonous plant belongs to *Malvaceae* family and native of Africa.Okra is high in protein, carbohydrates, and vitamin C[1] contents and plays a significant role in human nutrition. This nutritionally rich vegetable needs to be cultivated with balanced fertilization to achieve maximum yield with optimum use of plant nutrients. Application of site-specific balanced nutrients on crops can be achieved with fertilizer prescription equations through targeted yield approach as described by Ramamoorthy *et al*.[2]Application of nutrientson the basis of targeted yield resulted in higher yield, net benefit, and B:C ratio indicating its superiority over general fertilizer recommendation. Keeping the above facts in view, a field experiment was carried out to formulate targeted yield equations for Okraunder varying soil fertility levels.

2. Materials and Methods

The experiment was conducted at E block of the Central Research Farm of OUAT, Bhubaneswar. The experimental site was characterized by medium land, sandy loam in soil texture, acidic (pH 5.67) in soil reaction and medium (5.5 g kg^{-1}) in soil organic carbon content. Cation Exchange Capacity of the surface soil was 4.5 cmol (p^{+})kg^{-1}with 65 percent of base saturation. The experimental site was low in average soil available nitrogen (N), low to medium in average available phosphorus (P) and very low in average available potassium (K). The soil has been classified as fine, mixed, hyperthermic, *VerticUstochrepts* as per USDA soil taxonomy.

The experiment was started with creation of three soil fertility gradient stripes during *kharif*, 2020. Rice (cv. *Lalat*) was grown in these stripes by applying no N, P, K fertilizers in S-I, recommended dose of fertilizers (N:P: K at80:40:40 kg ha^{-1}) in S-II and double of the recommended dose (N:P:K at 160:80:80 kg ha^{-1}) in S-III strip.

Each strip was sub-divided into 24 sub-plots, from which soil samples were collected and were analyzed for soil organic carbon[3], available nitrogen[4], phosphorous[5] (Bray and Kurtz, 1945)and potassium[6] as outlined by Jackson[7]. In each strip, out of 24 sub-plots, 21 sub-plots were super imposed with different graded doses of N, P, K fertilizers; two sub-plots (22nd and 23rd) were applied with FYM at 5 t and 10 t ha^{-1}, respectively and the 24th plot was kept as absolute control. Different levels of fertilizers were applied at different combinations of NPK (Table 1) and Okra (cv. *Kajari*) was grown during *rabi*, 2020-21. Post-harvest soil samples, plant samples, yield data were recorded to study the nutrient uptake followed by formulation of targeted yield equations.

The required parameters to formulate fertilizer prescription equations for targeted yield of Okra were experimentally obtained for the given soil type-crop-agroclimatic condition. Nutrient requirement (NR), soil efficiency (Cs), fertilizer efficiency (Cf), and organic matter efficiency (Co) were calculated following the Ramamoorthy's inductive cum targeted yield model.
Therefore,

$$\text{NR (kg/ q)} = \frac{\text{Uptake of nutrient by Okra (kg/ ha)}}{\text{Yield of Okra (q/ ha)}}$$

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

$$\text{Cf (\%)} = \frac{\text{Uptake of nutrient in fertilizer treated plot (kg/ ha)} - [\text{Initial soil test value} \times \text{Cs}]}{\text{Nutrient applied through fertilizer (kg/ ha)}}$$

$$\text{Co (\%)} = \frac{\text{Uptake of nutrient in organic matter treated plot} - (\text{Initial soil test value} \times \text{Cs})}{\text{Nutrient applied through organic matter (kg/ ha)}}$$

All the parameters were calculated and combined for targeted yield equations as follows:

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

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

3. Results and Discussion

The experimental result showed that the highest soil nutrient was built up in the S-III strip among three fertility gradient stripes. The mean values of soil available NPK increased with increase in fertilizer doses from S-I to S-III strip. The mean available soil N was found to be 126.5,142.3 and 156.5 kg ha^{-1}, that of P_2O_5 was 25.5, 31.6 and 36.1 kg $ha^{-1}$and the mean available K_2O was 99.1, 107.1 and 118.3 kg ha^{-1} in S-I, S-II and S-III stripes, respectively. Higher soil fertility status, nutrient uptake and yield were observed in the S-III strip as the highest quantity of fertilizers were applied for rice during *kharif* and a large amount of applied nutrients might have remained unutilized after harvest of the crop. However, fruit yield was reduced, and biomass yield was increased when higher amounts of nutrients were applied in S-III strip owing to more vegetative growth of the crop. In contrast, the lowest yield and uptake were found in the S-I as no fertilizer was applied in rice during *kharif*. Similar observations have also been reported for French bean[8] and green gram[9].

The range and mean of initial soil test values, uptake of nutrients and fruit and biomass yield of Okra are presented in Table 2. Uptake of N, P and K shows an increasing trend with increase in fertility gradient stripes from S-I to S-III. The mean uptake of N was 51.6, 55 and 61.5 kg ha^{-1}, that of P was 19.8,20.8 and 22.9 kg ha^{-1} and mean K uptake was 35.6, 37.1and 36.7 kg ha^{-1} in S-I, S-II, and S-III stripes respectively. Results showed that yield increment is associated with the nutrient content in soil. The level of nutrients applied (N, P, K) correlated with the fruit yield and biomass yield of the crop to a certain extent as biomass yield increased with the applied nutrients whereas fruit yield was reduced. The average fruit yield of Okra ranged from 171.9 q ha^{-1}in the lowest fertility gradient strip (S-I) to 192.1 q ha^{-1} in the highest fertility gradient strip (S-III). Likewise, the average biomass yield of Okra ranged from 99.6q ha^{-1} in the lowest fertility gradient strip (S-I) to 118.5 q ha^{-1} in the highest fertility gradient strip (S-III). Similar observations were also recorded in different crops by the earlier workers[10,11].

The nutrient requirement (NR) for producing one quintal of Okra was 0.31kg N, 0.12kg P_2O_5 and 0.2kg K_2O. Soil efficiency (Cs) was found to be 26, 25 and 18 percent; fertilizer efficiency (Cf) was 21, 26 and 19 percent and organic matter efficiency (Co) was 35, 48 and 38 percent for N, P_2O_5 and K_2O, respectively (Table 3).

Targeted yield equations for Okra (*cv. Kajari*) were thus formulated without and with application of farm yard manure (Table 4). In the equations, the yield target (T) is to be fixed based on the yield potential of the crop and input supplying capacity, the SN, SP_2O_5 and SK_2O values stand for available soil nitrogen, soil phosphorus and soil potassium, respectively of the soil. The O N, O P_2O_5 and O K_2O values stand for nitrogen, phosphorus and potassium through organic sources. A ready reckoner for fertilizer doses can be used for achieving a specific yield target at different soil fertility levels (Table 5). These equations may be useful in red, laterite and yellow soils (*Inceptisols* and *Alfisols*) which constitute 84% of total geographical area of Odisha. Similar study and results were also reported by various workers in different crops like coriander[12] and Rice[13].

4. Conclusions

Fertilizer recommendation based on targeted yield equations for Okra is one of the most important tools for adopting site specific nutrient management. This will not only supply the required quantity of nutrients to achieve a specific yield target but also it maintains the soil fertility status. Thus, it prevents not only the application of over dose of costly nutrients input but also the crop suffering due to the insufficient supply of plant nutrients. Targeted yield approach may be advantageous for balanced fertilization on crop considering the availability of nutrient in soil and the requirement of crop.

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Table 1: Levels of nitrogen, phosphorus, potassium and FYM

N level (kg ha^{-1})	P_2O_5 level (kg ha^{-1})	K_2O level (kg ha^{-1})	FYM (t ha^{-1})
0	0	0	0
90	50	60	5
110	60	80	10
130	70	100	-

Table 2: Range and average yield of fruit and biomass of Okra (cv. *Kajari*), soil test values and NPK uptake in different fertility gradient stripes

Parameter	**Block-I**		**Block -II**		**Block-III**	
	Range	Mean ±SEm	Range	Mean ±SEm	Range	Mean ±Sem
Fruit yield (q ha^{-1})	150.1- 194.1	56.9±1.96	57.6 -194.7	164.1±1.95	173.3-222.3	177.1±1.96
Biomass yield(q ha^{-1})	76.5-115.8	99.6± 2.5	8.3-120.5	105.3± 1.8	94.2-145.8	118.5±1.96
Av. N (kg ha^{-1})	117.0-136.0	125.1± 1.1	134.2-147.8	141.7± 1.1	146.2-162.4	156.2± 0.9
Av. P_2O_5 (kg ha^{-1})	20.8-31.2	25.3± 0.6	26.8-35.9	31.4± 0.5	31.4-39.6	36.1± 0.5
Av. K_2O (kg ha^{-1})	93.8-107.3	99.1± 0.7	101.7-118.3	107.2± 0.8	11.0-123.8	118.5± 0.7
N uptake (kg ha^{-1})	30.9-61.8	72± 1.4	35.2-63.2	75.4± 1.1	40.9-77.2	82± 1.4
P uptake (kg ha^{-1})	6.5-22.9	20.3± 0.4	8.5-23.6	21.3± 0.3	12-27.8	23.3± 0.4
K uptake (kg ha^{-1})	15.3-40.1	29.3± 0.6	8.8 -41.1	30.7± 0.5	23.6-42.7	26.4± 0.5

Table 3: Basic data required for fertilizer adjustment equations of Okra in *Inceptisols*

Basic data	N	P_2O_5	K_2O
Nutrient requirement (kg q^{-1})	0.31	0.12	0.2
Soil efficiency (Cs, %)	26	25	18
Fertilizer efficiency (Cf, %)	21	26	19
Organic matter efficiency (Co, %)	35	48	38

Table 4: Fertilizer adjustment equations

Fertilizer dose	Without FYM	With FYM (IPNS)
Nitrogen (kg ha^{-1})	FN=1.45T-1.15SN	FN= 1.45T -1.15S N– 1.66 ON
P_2O_5 (kg ha^{-1})	FP_2O_5=0.49T–1.07S P_2O_5	FP_2O_5= 0.49T-1.07SP_2O_5– 1.84OP_2O_5
K_2O (kg ha^{-1})	FK_2O =0.91T – 0.86 SK_2O	FK_2O=0.9T- 0.86SK_2O-2 OK_2O
FN, FP_2O_5 and FK_2O= Nitrogenous, phosphatic and potassic fertilizers required (kg ha^{-1});T= Yield target (in quintals); SN, S P_2O_5 and S K_2O = Soil testing values of N, P_2O_5 and K_2O (in kg); O N, O P_2O_5 and O K_2O = Nutrients N, P_2O_5 and K_2O supplied through organic source (in kg)		

Table 5: Ready reckoner chart of fertilizer doses for different yield targets of Okra under varying fertility status(Fertilizer Nutrient Required in kg ha^{-1})

Initialstatus			T=175qha^{-1}			T=200qha^{-1}			T=225qha^{-1}		
N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
110	15	120	127.5	69.7	56.1	163.5	81.9	78.8	199.8	94.2	101.6
120	25	130	115.8	59.0	47.5	152.0	71.3	70.2	188.3	83.5	92. 9
130	35	140	104.3	48.3	38.9	140.5	60.6	61.6	176.8	72.8	84.4
140	45	150	92.8	37.6	30.3	129.0	49.9	53	165.3	62.1	75.8
155	55	160	75.5	26.9	21.7	111.7	39.2	44.4	148.0	51.4	67.2
170	65	170	58.25	16.2	20.0	94.5	28.5	35.8	130.8	40.7	58.6
185	75	180	41.0	15.0	20.0	77.3	17.8	27.2	113.5	30.0	49.9
190	85	190	35.25	15.0	20.0	71.5	15.0	18.6	107.8	19.3	41.4
200	95	200	27.5	15.0	20.0	60.0	15.0	20	96.3	15.0	32.8