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Soil test based optimal fertilizer doses for attaining different yield targets of jute in alluvial soils of West Bengal

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ABSTRACT

Soil-test-crop-response experiment on jute (JRO 204) was conducted on alluvial soils of West Bengal to assess the fertility status, nutrient requirement, and formulation of prescription equation (with and without integrated plant nutrient supply) for jute on soil test and targeted yield basis. By using yields, initial soil-test values, uptake of nutrients and fertilizer doses applied, the basic data [viz., nutrient requirement (NR), and contribution of nutrients from soil (Cs), fertilizers (Cf) and farmyard manure (Cfym) were computed and used to develop fertilizer prescription equation for jute with and without IPNS.A farmer can save nitrogen, phosphorus and potassic fertilizer in amounts of 4.30, 9.04 and 8.59 per cent more as compared to without IPNS in jute. The fertilizer doses were validated for attaining yield targets of 35 and 40 q ha^{-1} in farmer's field. Application of fertilizers as per ST-TY without and with FYM achieved the target of 40 q ha^{-1} fibre production of jute with (-) 3.43% and (+) 4.00% yield deviation, respectively. Jute yield within ±10% deviation was attained, which indicated that soil test based fertilizer dose was superior. This approach could be adopted for regions with similar soil and agro-climatic conditions to increase jute yield.

Keywords: Alluvial soils, jute, nutrient requirement, optimum fertilizer dose, soil test, yield target

Jute is one of the important cash crops and occupies a prestigious position in the industrial and agricultural economy of India. The fibre obtained from jute is popularly known as golden fibre. Jute fibre contributed about ₹ 5627 crore (0.37%) to India's value of output from agriculture during 2014-15. Total exports of jute sector were Rs. 2050 crore during 2015-16.The acerage under raw jute (jute and mesta collectively known as raw jute) has been dwindling for the last six decades, but it is seen that production in India has increased from 36 lakh bales to 115 lakh bales since independence. The productivity of jute had also doubled from 11.0 q ha^{-1} during 1950-51 to 25.77 q ha^{-1} during 2015-2016. Almost 85per cent of the world's jute cultivation is concentrated in the Ganges Delta.Increase in productivity of jute is possible through the introduction of high yielding and premature flowering resistant varieties along with location- specific improved crop production, protection and retting technologies. Crop yield response to nutrient application is a function of nutrient requirement, nutrient availability from indigenous sources and fate of fertilizer application in soil. Ultimately this will determine the availability and selection of fertilizer to be used to get a good crop yield (Dobermann *et al*., 2003). Total fertilizer nutrient consumption in West Bengal in 2012-13 was 1.56 million MT while removal of plant nutrients by the crops was to the tune of 1.75 million MT, indicating a gap of about 0.19million MT per anum, thereby resulting in fast declining of the fertility status of soils (IPNI). Blanket use of fertilizer in the field without knowledge on nutrient requirement by crop and availability of nutrient in soil may adversely affect both soil and crop (Ray *et al*., 2000). In addition to this with increasing demand for chemical fertilizer and depleting soil fertility, there is an urgent need to shift to integrated organic and inorganic sources of nutrients for sustainable crop production. The targeted yield approach was initially the concept of (Ramamoorthy *et al*., 1967). The approach was further modified by Kanwar (1971). As compared to the existing practice of general fertilizer recommendation, application of soil test and target yield based fertilizer dose to a crop has been recognized as a better approach because it would result in greater response ratio and greater benefit-cost ratio. Nutrient imbalance in the soil would be rectified as the nutrients are applied in proportion to the magnitude of deficiency of particular nutrients. The STCR experiments were conducted with the basic assumption that fertilizer recommendations would depend on the crop response, in which spatial variability has to be minimized for every independent variable affecting crop yield except for the nutrient in question, although many non-fertility variables (*viz*., soil texture, bulk density, available water content) and other fertility variables would significantly impact the crop yield. In the present study, the relationship between the nutrients supplied by the soil and added fertilizers, the nutrient uptake by plants and yields of jute we assessed. Later, soil test based optimum fertilizer

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Table 1: Treatment structure of jute

No.	Treatment combinations			Nutrient levels(kg ha^{-1})			FYM(t ha^{-1})
	N	P	K	N	P_2O_5	K_2O	
1	0	0	0	0	0	0	0
2	1	2	2	40	40	40	0
3	2	3	2	80	60	40	0
4	2	2	2	80	40	40	0
5	3	2	2	120	40	40	0
6	2	1	2	80	20	40	0
7	3	2	1	120	40	20	0
8	2	3	3	80	60	60	5
9	2	2	1	80	40	20	5
10	1	1	2	40	20	40	5
11	3	3	2	120	60	40	5
12	1	3	2	40	60	40	5
13	0	0	0	0	0	0	5
14	3	2	3	120	40	60	5
15	1	2	1	40	40	20	10
16	2	1	3	80	20	60	10
17	3	3	3	120	60	60	10
18	2	2	3	80	40	60	10
19	1	1	1	40	20	20	10
20	2	1	1	80	20	20	10
21	0	0	0	0	0	0	10

recommendation for attainingdesirable yield target of jute under alluvial soils in eastern India we developed. Field verification trials were conducted to verify the validity of fertilizer prescription equations developed for jute..

MATERIALS AND METHODS

A field experiment was conducted during 2011-12 under All India Coordinated Research Project on Soil Test Crop Response Correlation at ICAR-Central Research Institute for Jute and Allied Fibres, Barrackpore, Kolkata (West Bengal). The site is located at 22º452 N latitude, 88º262 E longitude and at an altitude of 9 m above the mean sea level and has sub-humid to humid subtropical climate. The average annual rainfall is 1066 mm and the soils are alluvial Typic Eutrochrept with sandy loam texture. The surface soil of the experimental field is moderately deep, well-drained, sandy clay loam in texture with pH 7.1, electrical conductivity (EC) 0.031 Sm-1, and cation exchange capacity of22.7cmol (p+) kg^{-1} confined to lower Gangetic alluvium. The initial oxidizable soil organic carbon (OC), soil available alkaline potassium permanganate (KMnO4) nitrogen, Olsen phosphorus (P) and extractable ammonium acetate (NH_4OAc) potassium (K) levels were 0.73%, 273, 88.5 and 196 kg ha^{-1}.

In the gradient experiment, variation in soil fertility was created by adopting the inductive methodology outlined by Ramamoorthy, Narasimhan and Dinesh (1967) and later modified by Ramamoorthy and Velayutham (1971). For this purpose, the experimental field was divided into three equal rectangular strips; the first strip received no fertilizer ($N_0P_0K_0$), the second and third strips received $N_{100}P_{80}K_{100}$ and $N_{200}P_{160}K_{200}$, respectively and a gradient crop of fodder maize (cv. J-1006) was grown as an exhaust crop. Soil samples were collected after the harvest of the gradient crop and analyzed for alkaline $KMnO_4$-N, Olsen-P and NH_4OAc extractable K following standard procedures (Tandon, 1993).Subsequently, each strip was divided into 3 blocks for applying FYM (0, 5 and10 t ha^{-1}).Each block divided into 7 plots. Hence, each strip is divided into 21 plots.The experiment was laid out in a fractional factorial design with four levels of N (0, 40, 80 and 120 kg ha^{-1}), P_2O_5 (0, 20, 40 and 60 kg ha^{-1}) and K_2O (0, 20 40 and 60 kg ha^{-1}) and three levels of FYM (0, 5 and10 t ha^{-1}) constituting 21 treatment combinations. The 18 fertilizer treatments and three controls were randomized in three blocks comprising seven treatments within a strip randomized in such a way that all the 21 treatments were present in all the strips (Table 1). Fertilizer P and K were applied as basal while N was applied in three equal splits (*i.e*. basal and 21 and 40 days after sowing). FYM was incorporated during land preparation. The crop was grown to maturity and the fresh weights and dry weights of jute samples were recorded. From each plot, plant samples were collected, processed and analysed for N, P and K contents and the NPK uptake values were computed using the dry matter yield and nutrient contents.

The basic parameters i.e., nutrient requirement (NR), contribution of nutrients from soil (Cs) and fertilizers (Cf)were calculated as described by Ramamoorthy *et al*. (1967). The percent contribution of nutrients from the applied FYM, *viz*., CFYM was estimated as described by Santhi *et al*. (1999).

Nutrient requirement (kg q^{-1})

$$\text{Nutrient Requirement of fibre production} = \frac{\text{Nutrient uptake of N.P.K. (Kg ha}^{-1})}{\text{Yield of fibre (q ha}^{-1})}$$

Percentage of nutrient contribution from soil to total nutrient uptake (Cs)

$$\text{Cs} = \frac{\text{Total uptake of N.P.K. (Kg ha}^{-1})}{\text{Soil test values for available N.P.K. from control plot (kg ha}^{-1})} \times 100$$

Percentage of nutrient contribution from fertilizer to total nutrient uptake (Cf)

Cf = Total uptake of N.P.K. in treated plot (kg ha^{-1})

$$-\frac{\text{soil test value for available N.P.K. in treated plot (kg ha}^{-1})\times\text{average Cs}}{\text{fertilizer N.P.K.applied (kg ha}^{-1})} \times 100$$

Percentage of nutrient contribution from organic to total uptake (Cfym)

Cfym = Total uptake of N.P.K in FYM treated plot (kg ha^{-1})

$$-\frac{\text{soil test value for available N.P.K. in FYM treated plot (kg ha}^{-1})\times\text{average Cs}}{\text{fertilizer N.P.K. added through FYM (kg ha}^{-1})} \times 100$$

These parameters were used for deriving soil test based fertilizer recommendations in the form of ready reckoner for desired yield targets of jute under NPK alone as well as IPNS.

Creation of targeted yield equations

Fertilizer prescription equation for targeted yield of jute was formulated by using the basic parameters [*viz*., nutrient requirement (NR) and contributions of nutrients from soil (Cs), fertilizers (Cf), and farmyard manure (Cfym)] with and without IPNS. To achieve the desirable yield target, lower fertilizer doses were required for IPNS as compared to without IPNS. Contribution from Farmyard manure (FYM) was included in the equation system and amount of fertilizers for getting desirable yield targets reduced under the IPNS system.

By using these parameters, the fertilizer prescription equations were developed for jute as follows.

$$\text{FN (Without Organic)} = \left(\frac{\text{NR}}{\frac{1.1}{100}}\right)\text{T} - \frac{\text{Cs}}{\text{Cf}} \times \text{SN}$$

$$\text{FN (With Organic)} = \left(\frac{\text{NR}}{\frac{1.1}{100}}\right)\text{T} - \frac{\text{Cs}}{\text{Cf}} \times \text{SN} - \frac{\text{Cfym}}{\text{Cf}} \times \text{ON}$$

Fertilizer Phosphorus (FP_2O_5)

$$\text{FP}_2\text{O}_5\text{ (Without Organic)} = \left(\frac{\text{NR}}{\frac{1.1}{100}}\right)\text{T} - \frac{\text{Cs}}{\text{Cf}} \times 2.29 \times \text{SP}$$

$$FP_2O_5 \text{ (With Organic)} = \left(\frac{NR}{\frac{1.1}{100}}\right) T - \frac{Cs}{Cf} \times 2.29 \times SP - \frac{Cfym}{Cf} \times 2.29 \times OP$$

Fertilizer Potassium (FK_2O)

$$FK_2O \text{ (Without Organic)} = \left(\frac{NR}{\frac{1.1}{100}}\right) T - \frac{Cs}{Cf} \times 1.21 \times SK$$

$$FK_2O \text{ (With Organic)} = \left(\frac{NR}{\frac{1.1}{100}}\right) T - \frac{Cs}{Cf} \times 1.21 \times SK - \frac{Cfym}{Cf} \times 1.21 \times OK$$

where FN, FP_2O_5, and FK_2O are fertilizer N, P_2O_5, and K_2O dose (kg ha^{-1}); SN, SP,and SK are available soil-test values of N, P, and K (kg ha^{-1}); NR is nutrient requirementof N, P, and K in kg q^{-1} of fibre/grain/green pod production; Cs is percentage contributionfrom soil; Cf is percentage contribution from fertilizer nutrient without FYM; Cfymis percentage contribution of nutrients from farmyard manure (FYM); ON is quantity of N applied through FYM; OP is quantity of P applied through FYM; OK is quantity of K applied through FYM; and T is yield target (q ha^{-1}).

The fractional factorial design was used for analysis of jute data as per the standard procedure of STCR correlation study. Under fractional factorial design, using yield data as the dependent variable and soil available nutrients, nutrient uptake, fertilizer nutrients, and interactions between soil and fertilizer nutrients as independent variables, data were analysed and presented on the mean basis (Sukhatme and Amble, 1978).

To validate the optimum fertilizer doses for attaining yield targets of jute using adjustment equationsbased on soil tests, field verification trials were conducted during 2014. Seven treatments were tested under seven farmers' fields of Haringhata, Nadia district: control (T_1), farmers' practice (T_2), general recommended dose (T_3), yield target 35 q ha^{-1} (T_4), yield target 35 q ha^{-1} +FYM @ 10 t ha^{-1} (T_5), yield target 40 q ha^{-1} (T_6), and yield target 40 q ha^{-1}+FYM was applied @ 5 t ha^{-1} (T_7). Standard agronomic practices were followed for growing the jute crop. The crop was harvested after maturity and theyield of jute was recorded.

RESULTS AND DISCUSSION

Fertility gradient establishment experiment

Variation in soil fertility was created by applying graded fertilizer doses and growing an exhaust maize crop for natural transformation of the added nutrients. After harvest of the maize crop, soil samples were collected from each plot and analyzed. Strip wise mean green fodder yield of maize and mean soil test values for N, P and K as given in table- 2 indicated the creation of fertility gradients from strips I to III. The maximum green fodder yield (15.8 t ha^{-1}) and fertility status (298, 115, 222 kg N, P and K ha^{-1}, respectively) were recorded in strip III which was due to the greatest amount of fertilizers applied and lower nutrient uptake due to lower seed rate.

STCR experiment

The amount of nutrients absorbed by the crop influences the production. The amount of nutrients required to produce 100 kg of jute fibre were found to be 2.86 kg N, 0.83 kg P and 5.81 kg K (Table 3). Potassium requirement was maximum in jute which might be due to greater uptake of K by jute biomass, which increased the potassium requirement in jute.

Contribution of N, P and K as estimated from soil and fertilizer sources were 21.09, 20.34, 76.60 and 42.18, 43.83 and 174.9 per cent respectively. Results indicated that nutrient contribution from fertilizer sources was greater than that from the soil source and it is observed that contribution of K for jute was observed to be more than 100 per cent, which seems to be due to high plant uptake of this nutrient as luxury consumption. Similar type of higher efficiency of potassic fertilizer was also reported for jute by Singh *et al.* (2015) in Inceptisols, rice by Bera *et al*. (2006), and maize by Reddy *et al*. (2000). The efficiencies of organic source of FYM were found to be 8.8% for N, 11% for P and and 19.3% for K in jute crop.

Using fertilizer prescription equation, fertilizer requirements for N, P_2O_5 and K_2O at different soil test

Table 2: Green maize fodder yield and post-harvest soil test values in different fertility gradients after maize harvest

Strips	Fertility gradients	Fertilizer doses ($kg\ ha^{-1}$)			Green fodder yield ($t\ ha^{-1}$)	Post-harvest maize soil test values			
		N	P_2O_5	K_2O		OC (%)	Avg. N ($kg\ ha^{-1}$)	Avg. P ($kg\ ha^{-1}$)	Avg. K ($kg\ ha^{-1}$)
ST-I	L_0	0	0	0	6.83	0.67	276	82.2	126.8
ST-II	L_1	100	80	100	11.27	0.67	288	98.9	192.2
ST-III	L_2	200	160	200	15.78	0.69	298	114.7	221.6

Table 3: Basic data and fertilizer adjustment equations for jute (cv. JRO 204)

Nutrients	Basic data				Fertilizer adjustment equations
	NR ($kg\ q^{-1}$)	CS (%)	CF (%)	CFYM (%)	
N	2.86	21.09	42.18	8.82	FN= 6.80T-0.50SN-0.21ON
P_2O_5	0.83	20.34	43.83	10.97	FP= 1.90T-0.46SN- 0.15OP
K_2O	5.81	76.60	174.9	19.29	FK = 3.32T-0.44SK – 0.11OK

Table 4: Soil- test-based fertilizer prescription under IPNS for specific yield targets of jute (35 and 40 $q\ ha^{-1}$) in alluvial soils

Parameter	NPK alone	NPK+FYM ($5\ t\ ha^{-1}$)	Reduction over NPK alone (%)	NPK alone	NPK+FYM ($5\ t\ ha^{-1}$)	Reduction over NPK alone (%)
$KMnO_4$ N ($kg\ ha^{-1}$)		35 $q\ ha^{-1}$			40 $q\ ha^{-1}$	
200	138	133	3.80	172	167	3.05
225	126	120	4.18	160	154	3.29
250	113	108	4.65	147	142	3.57
275	101	95	5.22	135	129	3.90
300	88	83	5.97	122	117	4.30
325	76	70	6.95	110	104	4.79
350	63	58	8.33	97	92	5.41
375	51	45	10.4	85	79	6.21
400	38	33	13.8	72	67	7.29
Olsen P ($kg\ ha^{-1}$)						
15	60	56	6.29	69	65	5.43
30	53	49	7.12	62	58	6.03
45	46	42	8.19	55	52	6.78
60	39	35	9.64	48	45	7.75
75	32	28	11.7	42	38	9.04
90	25	21	14.9	35	31	10.8
105	18	14	20.6	28	24	13.5
120	11	8	33.2	21	17	18.0
135	4	1	83.8	14	10	27.0
NH_4OAcK ($kg\ ha^{-1}$)						
125	61	57	6.29	78	74	4.95
150	50	46	7.67	67	63	5.76
175	39	35	9.82	56	52	6.90
200	28	24	13.7	45	41	8.59
225	17	13	22.4	34	30	11.4
250	6	4	35.5	23	19	16.9
275	0	0	0.0	12	8	32.6

Table 5: Mean fibre yield, nutrient uptake, and yield response of jute with FYM levels under different fertility gradients

Sl. No.	Parameters	ST-I /L0 Gradient	ST-II /L1 Gradient	ST-III /L2	Over all mean
	FYM: 0 t ha^{-1}				
1.	Fibre yield (kg ha-1)	2933	3200	3151	3095
2.	Uptake - N (kg ha-1)	75.75	88.41	104.6	89.59
3.	Uptake - P (kg ha-1)	21.28	24.48	29.31	25.02
4.	Uptake - K (kg ha-1)	150.9	184.8	201.4	179.0
5	Yield resp. (kg ha-1)	1214	977	717	969
	FYM: 5 t ha^{-1}				
1.	Fibre yield (kg ha-1)	3032	3033	3328	3131
2.	Uptake - N (kg ha-1)	76.65	93.33	110.5	93.49
3.	Uptake - P (kg ha-1)	22.22	25.50	31.78	26.50
4.	Uptake - K (kg ha-1)	150.2	175.1	215.4	180.2
5.	Yield resp. (kg ha-1)	1313	810	894	1006
	FYM: 10 t ha^{-1}				
1.	Fibre yield (kg ha-1)	2941	3231	3712	3294
2.	Uptake - N (kg ha-1)	73.92	103.3	110.6	95.94
3.	Uptake - P (kg ha-1)	22.66	27.16	32.06	27.29
4.	Uptake - K (kg ha-1)	153.4	195.9	233.9	194.4
5.	Yield resp. (kg ha-1)	1222	1008	1278	1169

Table 6: Economics of verification trial of jute (JRO204)

Treatments	Fertilizer doses (kg ha^{-1})			Fibre yield (q ha^{-1})	Addln yield over control (q ha^{-1})	Resp. ratio (kg kg^{-1} NPK)	Gross income (₹ ha^{-1})	Cost of fertilizer (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net return (₹ ha^{-1})	Yield deviation (%)	B:C ratio
	N	P_2O_5	K_2O									
Control	0	0	0	21.3			48924		35000	13924		1.4
FP	59	50	50	28.8	7.5	4.73	66207	4693	39693	26514		1.7
RD	80	40	40	30.4	9.1	5.69	69854	4185	39185	30670		1.8
ST-TY(35q ha^{-1})	89	40	19	34.0	12.7	8.65	78151	3695	38695	39456	-2.92	2.0
ST+FYM (35 q ha^{-1})	82	36	18	37.1	15.8	11.66	85363	5906	40906	44457	6.04	2.1
ST-TY (40 q ha^{-1})	123	49	24	38.6	17.4	8.85	88846	4771	39771	49075	-3.43	2.2
ST+FYM (40 q ha^{-1})	116	46	22	41.6	20.3	11.07	95680	6938	41938	53742	4.00	2.3

values for the production of 35 and 40 q ha^{-1} was calculated without FYM and with 5 and 10 tons of FYM ha^{-1} (Table 4). The results revealed that fertilizer requirement increased with increasing yield targets of jute and decreased with increasing soil test values. The estimates showed that for a yield target of 40q ha^{-1} of jute fibre with soil test values of 300, 75, 200 kg ha^{-1} of $KMnO_4$ N, Olsen P, and NH4OAc K, the doses of nutrients required were 122,42, 45 kg ha^{-1}, respectively. When FYM @ 10 t ha^{-1} were applied along with NPK, the required fertilizer N, P2O5 and K2O were 117, 38, 41 kg ha^{-1}, respectively. This clearly reflects that IPNS can save N, P_2O_5 and K_2O in amounts of 4.3, 9.04 and 8.59 per cent in jute over that required without IPNS and overall there was net savings of fertilizers for each target, which in turn will maintain soil quality and soil health based on judicious use of organics and inorganics and also net return to the farmers. Similar type of fertilizer savings under IPNS was also reported for potato by Gayathri *et al*. (2009), cotton by Praveena Katharine *et al*. (2013) *etc*.

The results in table 5 showed the mean values of jute yields, nutrient uptake and yield response in relation to the fertility gradients. Increasing trend in jute yield and nutrient uptakes were observed from the gradients of L_0 to L_2, which clearly indicate that high fertility status favors the jute production. Similarly, increasing FYM application in different gradients also increased jute yield. Application of FYM @ 5 and 10 t ha^{-1} increased yields of jute by 1.2 and 6.4 per cent over no FYM application. Highest yield response was observed in the highest fertility gradient with application of FYM@ 10 t ha^{-1} which could be due to a steady decomposition of FYM and slow release of nutrients throughout the growth period of jute for better assimilation of nutrients. Uptake of N, P, K increased with application of higher dose of FYM. Singh *et al*. (2015) reported that the uptake of N, P and K increased with application of greater doses of FYM.

Verification trials

Field verification trials are important because the calibration of results obtained in a research farm have to be tested for their validity under farmers' field condition. The objectives of these trials were to test the validity of the results obtained from the main experiment before recommending them for adoption by extension agencies and to convince the farmers about greater profitability and efficiency of the soil test based fertilizer recommendation than general recommended dose. Using the prescription equations fertilizer doses were calculated for 35q ha^{-1} and 40 q ha^{-1} of jute and were compared with recommended dose of fertilizers (RDF) and farmers' practice. Results of the trials showed that the deviation in yield obtained from the targeted yield equation ranged from (-) 3.43% to (+) 6.04%which were within ± 10% deviation of the yield target. The farmer's practice of fertilizer application and control were less efficient in producing fibre yield of jute.

Net monetary returns and benefit cost ratio were higher in treatments where fertilizer were applied based on soil test target yield approach as compared to farmers' practice and general recommended dose of fertilizer treatments.

The net return and B:C ratio was further increased by about ₹ 4667 to Rs. 5000 $ha^{-1}$when FYM was included in the fertilizer prescription (Table 6). Among the seven different treatments evaluated in the field verification trial, integration of FYM (@ 5 t ha^{-1}) along with fertilizers dose based on ST-TY (35q ha^{-1}) recorded the highest response ratio (11.66 kg kg^{-1} NPK) over RDF (5.69 kg kg^{-1} NPK) and farmers' practice (4.73 kg kg^{-1} NPK) while integration of FYM (5 t ha^{-1}) along with fertilizers dose based on ST-TY (40 q ha^{-1}) treatment recorded highest B:C ratio (2.3) over all treatments including RDF (1.8) and farmers practice (1.7). Between the two targets verified, targeting for lower yield *i.e*., 35 q ha^{-1} recorded relatively higher response ratio than that with 40 q ha^{-1} which might be due to better use efficiency of applied NPK fertilizers at low yield target levels (Bera *et al*., 2006). Compared to the RDF, the fertilizer application based on targeted yield approach was found to be superior. These are in conformity with the results obtained in rice (Sharma *et al*., 2015), in wheat (Bhaduri and Gautam, 2013), in onion (Saxena *et al*., 2008), mustard (Chand *et al*., 2006), in sugarcane (Potdar *et al.*, 2014) and in potato (Chatterjee *et al*., 2010).

The study indicated that soil test and targeted yield based fertilizer recommendation will not only ensure sustainable crop production, but will also reduce cost of cultivation, increase fertilizer use efficiency, increase income of farmer and minimize environmental pollution. Soil health and soil quality will be maintained and economic status of the farmers will be improved. The soil test based targeted yield equation will ensure sustainable crop production by increasing fertilizer use efficiency, minimizing the cost of cultivation, reducing environmental pollution and maintaining soil health with the balanced use of organic manure and chemical fertilizers. In addition, it will also facilitate the farmers towards the economic use of costly fertilizers, thereby improving the overall financial status of the farmers. Therefore the soil test based fertilizer recommendation developed for jute would be the useful tool for balanced fertilization of nutrients.

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