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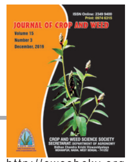

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Efficient nutrient management for profitable quality *tossa* jute (*Corchorus olitorius* L.) seed production in the intensively jute fibre growing southern Bengal region

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ABSTRACT

Field trial was laid for two successive years in 2019-20 and 2020-21 in TypicUstochrept soil of neutral reaction (pH 7.1) with medium organic carbon (OC) status (5.51 g kg^{-1}) and having available N, P, K: 296, 33 and 152 kg ha^{-1} at Nilganj, North 24 Parganas, West Bengal for understanding the consequence of dose of primary nutrients and application methods of fertilizer (especially N) on the seed yield, seed quality and profitability in tossa jute (Corchorus olitorius L.) (cv. JRO 204) in the intensively jute fibre growing southern Bengal districts. The peak jute seed yield of 1103 kg ha^{-1} was obtained withT_7[i.e., N 80 (in 3 splits of ½ at 21-28 DAS, ¼ at 42 DAS and ¼ at 56 DAS), P_2O_5 40, K_2O 80 kg ha^{-1}];and 3 split applications of N gave 7.6% more seed yield. Regarding jute seed quality, the same T_7 treatment produced seeds of the highest test wight (2.294 g) with the maximum vigour index (2205). Application of N, P, K gave positive balance of available nutrients of 40-57, 5 and 27 kg ha^{-1}, respectively N in 3 splits resulted higher agronomic efficiency of applied nutrients to the tune of 8.21 to 16.81% more as compared to the 2 split applications. The highest net return from the jute seed production was ₹ 87,294 ha^{-1} and the highest net return per rupee investment (NRPRI) was 1.73 in N_{80} (3 splits), P_{40} and K_{80} treatments.

Keywords: *Tossa* Jute, *Corchorus olitorius*, nutrient management, seed yield, quality of seed, seed economics

Reputation of jute in contributing to the rural as well as jute mill dominated peri-urban economy of eastern Indian states like West Bengal, Bihar, Assam, Meghalaya and Odisha is well known. It may be noted that about 5000 tonnes of quality seed are essential for sowing about 8 (± 5%) lakh hectare cultivated area of jute in India. Whereas, yearly production of certified jute seeds is about 1600 to 2100 tonnes, which meets the requirement of only 2.8 lakh hectare of total jute area of India. In West Bengal the intensively jute fibre growing districts are Murshidabad, Nadia, Coochbehar, Uttar Dinajpur, North 24 Parganas, Hooghly, Dakshin Dinajpur, Malda, Jalpaiguri, Alipurduar, Purba Bardhaman. The total jute area of West Bengal for fibre production is 5.5 (± 6%) lakh ha. Out of which, at present about 20% area is line sown (1.10 lakh ha) and 80% is under broadcast sowing (4.4 lakh ha). Considering the jute seed rate of 4 kg ha^{-1} for line sowing and 7 kg ha^{-1} for broadcast sowing, the total requirement of jute seed for West Bengal is about 3520 tonnes every year. Jute seed is conventionally produced in the drier tracts of India particularly in Andhra Pradesh (now part of Telangana), Maharashtra and Karnataka states (Sarkar *et al*., 2013). The produced jute seed is then brought to West Bengal, Bihar, Assam, Odisha, Meghalaya and other jute producing north-eastern states. So, for the entire amount of jute seed requirement, like other states, till date West Bengal rely on southern or western states who generally grow jute seed. Therefore, availability of jute seed in appropriate time to the fibre producing states (including West Bengal) is not guaranteed; at the same time, on road transportation cost and other related obvious reasons escalate jute seed price. This enhanced price of such jute seeds from other states is not conducive for the resource poor small and marginal farmers. So, it is an urgent need to develop technology for production of jute seed in the fibre producing zones itself, say southern Bengal condition. Most of the earlier work on efforts to produce jute seed are for other districts of West Bengal, where jute fibre is not produced, such as at Jhargram of Paschim Midnapore district (Sarkar and Banerjee, 2014), at red and laterite zone (Patra *et al*., 2017; Ghosh *et al*., 2018). Some effort was made for jute seed production under terai condition of West Bengal (Patra *et al*., 2016). Similar efforts had been made to produce jute seed in the non-traditional western Odisha (Sarkar, 2017; Sarkar *et al*., 2020). At the same time the method of application of fertilizers (especially N) to jute seed crop is mostly basal only. But as the majority jute fibre growing soils are loamy or sandy loam, there is leaching of N fertilizers from the rhizosphere to downwards, which is of no use for crop

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growth. So, application of N fertilizer in splits might have better nutrient use efficiency and higher seed yield with better seed quality. Thus, the concerned experiment was designed in the field to acquire knowledge of the dose and application method of nutrients for higher productivity of jute seed in the fibre growing southern Bengal condition.

MATERIALS AND METHODS

During two successive years of 2019-20 and 2020-21, experiment was laid and conducted in the J.S. Patel farm of ICAR-CRIJAF (22.7625°N, 88.4239°E, 9.6 m AMSL) Nilganj, North 24 Parganas, West Bengal with 4 levels of fertilizers [(i) no fertilizer, (ii) N 80 kg, (iii) N 80, P_2O_5 40 kg, (iv) N 80, P_2O_5 40, K_2O 80 kg ha^{-1}) and two ways of N use [(i) ½ of N at 21-28 days after sowing (DAS) just after weed removal and plant thinning and ½ N at 42 DAS immediately after removal of apical bud; (ii) ½ N at 21-28 DAS; ¼ N at 42 DAS; and ¼ N at 56 DAS] in Randomized Block Design (RBD) with 7 treatment combinations replicated 3 times (21 plots) having individual plot size of 6 m x 4 m, for understanding the significance of application method and amount of added nutrients on seed yield factors, seed yield and quality of jute seed (cv. JRO 204) in southern Bengal condition. During the experimentation period (September to December), the T_{max} varied between 33.8 and 23.2 °C and the T_{min} varied between 25.9 and 10.9 °C. During the period, the RH_{max} was 97.0-89.3% (at 06:36 hrs) and the RH_{min} was 52.0-69.4% (at 13:36 hrs).The soil of the concerned experimental field belongs to Typic Ustochrept with sandy loam texture having general characteristics: pH (1:1.25 w/v) in water 7.1, OC 5.51 g kg^{-1}, available N 296, P_2O_5 33 and K_2O 152 kg ha^{-1}. In 2019-20, the seed crop was sown on 4th September and harvested on 31st December at 119 days crop age and in 2020-21, the seed crop was sown on 2nd September and harvested on 26th December at 116 days of crop age. Standard agronomic (except nutrient management) and recommended standard plant protection procedures were followed for the experimental jute seed crop. For saving the jute seed from disease infection, carbendazim 50 WP @ 0.2% was applied at pod setting phase of the jute seed crop (Sarkar *et al*., 2016). Biometric observations on number of branches, pods in each plant, seed number in each pod, test weight (1000 seed weight in g), and yield of jute seed per net plot were noted. The seeds were then dried under the sun and quality parameters were tested. Germination percentage, speed of germination, seedling dry matter (SDM), vigour index (VI), were measured in the seed quality laboratory. Arbitrarily chosen 1000 seeds (7.50 ± 0.05% moisture) were weighed using a precision balance (of Sartorius Research, Germany) to find the test weight. Germination test on (Whatman no. 1) filter paper was conducted as advised by earlier researchers (Khandakar and Bradbeer, 1983). Randomly chosen 20 normal seedlings of 96 hours age in petridish were oven dried at 65 °C for 24 hours and the weight was taken as seedling dry matter (SDM). The value of seedling vigour index was calculated as suggested by Ram *et al*., (1991). Speed of germination was computed by the following formula given by Sen and Ghosh, (2006):

$$\text{Speed of germination} = \frac{n1}{d1} + \frac{n2}{d2} + \frac{n3}{d3} + \frac{n4}{d4}$$

where, n_1 … n_4 are the number of seedlings removed matching to the removal day number i.e., d_1 …. d_4

All the data were statistically analysed by WASP Agri Stat Package developed by ICAR-Goa and for Principal Component Analysis (PCA) XLSTAT,v.2021 was used.

RESULTS AND DISCUSSION

Effect on yield parameters of jute seed

It was observed that the pods per plant was the highest (28.7) in T_7 (N 80 kg, P_2O_5 40 kg, K_2O 80 kg ha^{-1} (here P_2O_5 denoted as P and K_2O denoted as K) where ½ of total N given at 21-28 DAS at the time of weeding and thinning; ¼ N given at 42 DAS just after removal of apical bud; and ¼ N given at 56 DAS when active branching occurred) and the least number of pods per plant was counted in no fertilizer cases (13.8). Likewise, the highest count of seeds per pod (218) was recorded in T_7 and without fertilizer plots showed the least number of seeds per pod (147). Branches per plant also trailed the same tendency as of pod number per plant and seed count per pod (Table 1).

Seed yield of jute

The seed yield of jute varied as like as yield parameters with different quantities and application methods of fertilizer (Table 1). The jute seed yield of 1103 kg ha^{-1} was the highest which was obtained in T_7 (i.e., N 80, P 40, K80 kg ha^{-1} where ½ N given at 21-28 DAS,¼ N applied at 42 DAS and the balance ¼ N given at 56 DAS). Application of N only @ 80 kg ha^{-1}gave 60.6% more yield in jute when compared with the yield obtained from zero fertilization (547.1 kg ha^{-1}). N 80kg along with 40 kg P improved the seed yield by 75.2% and N 80, P 40 and K 80 kg produced 94.5% higher seed yield in jute in comparison to the seed yield harvested in case of no fertilizer use. Applications of N in three splits (½ at 21-28 DAS, ¼ at 42 DAS and ¼ at 56 DAS) produced about 7.6% additional seed yield of jutet than the seed yield resulted from two splits of N (½at 21-28 DAS and ½ at 42 DAS). In a recent study, comparable findings were reported by Sarkar *et al*.

Table 1: Yield parameters and seed yield of *olitorius* jute seed as influenced by method of application and amount of applied fertilizer (pooled data of two years)

Treatments	Number of branches per plant	Pod number per plant	Number of seeds per pod	Seed yield (kg ha^{-1})
T_1: No fertilizer	8.63	13.77	147.47	547.08
T_2: N_{80} (2 splits)	11.71	23.39	193.60	853.27
T_3: N_{80} (3 splits)	12.39	23.67	196.89	903.66
T_4: N_{80} (2 splits) P_{40}	13.18	24.56	200.22	941.86
T_5: N_{80} (3 splits) P_{40}	13.17	24.94	200.47	974.68
T_6: N_{80} (2 splits) P_{40} K_{80}	15.20	27.33	216.83	1024.75
T_7: N_{80} (3 splits) P_{40} K_{80}	15.31	28.72	218.05	1103.01
LSD (0.05)	**0.675**	**3.144**	**13.560**	**83.780**

Table 2: Influence on jute seed quality as affected by method and quantum of fertilizer nutrients (pooled data of two years)

Treatments	1000 seed weight (g)	Germination (%)	Speed of germination (%)	Seedling weight (mg/20 seedlings)	Vigour index	Seed infection (%)
T_1: No fertilizer	1.781	98.83	94.67	16.93	1672.86	0.32
T_2: N_{80} (2 splits)	1.853	98.83	93.33	18.70	1848.83	0.43
T_3: N_{80} (3 splits)	2.143	99.17	94.33	18.69	1854.37	0.45
T_4: N_{80} (2 splits) P_{40}	2.156	99.67	95.67	20.11	2004.85	0.42
T_5: N_{80} (3 splits) P_{40}	2.153	99.33	94.83	20.13	2000.15	0.41
T_6: N_{80} (2 splits) P_{40} K_{80}	2.221	99.67	95.83	22.12	2205.04	0.33
T_7: N_{80} (3 splits) P_{40} K_{80}	2.294	99.50	94.83	22.14	2203.49	0.31
LSD (0.05)	**0.043**	**NS**	**N**	**0.584**	**65.02**	**NS**

Table 3: Outcomes of nutrient management parameters on available primary nutrients in soil and agronomic efficiency of nutrients

Treatments	Seed yield (kg ha^{-1})	Available nutrient status (kg ha^{-1}) after harvest of jute seed crop			Agronomic efficiency of nutrients
		N	P_2O_5	K_2O	
T_1: No fertilizer	547.1	273.05	30.11	143.27	-
T_2: N_{80} (2 splits)	853.3	336.14	31.12	146.18	3.82
T_3: N_{80} (3 splits)	903.7	340.85	30.84	144.33	4.45
T_4: N_{80} (2 splits) P_{40}	941.9	342.95	38.10	143.95	3.29
T_5: N_{80} (3 splits) P_{40}	974.7	349.41	38.16	144.15	3.56
T_6: N_{80} (2 splits) P_{40} K_{80}	1024.7	352.58	38.50	179.03	2.38
T_7: N_{80} (3 splits) P_{40} K_{80}	1103.0	352.97	38.55	179.25	2.78
LSD (0.05)	**83.78**	**31.361**	**3.276**	**15.245**	**0.775**

[*Agronomic Efficiency = {(seed yield from treatment plot) – (seed yield from control plot)}/Amount of nutrients added*]

(2019) and earlier report corroborates the present findings (Bhattacharjee *et al*., 2000).

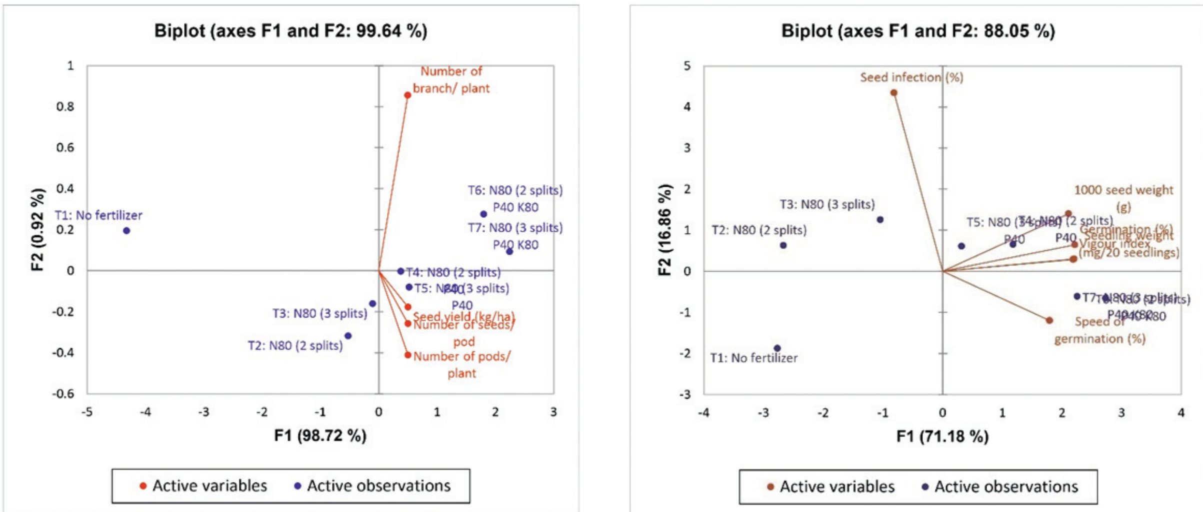
Seed quality of jute

The weight of 1000 numbers of seed (referred as 'test weight') of jute significantly differed with quantum of fertilizer and application methods (Table 2). The maximum test weight (2.294 g) was found in T_7 and the minimum of the same weight was recorded in no fertilizer cases (1.781 g). Differences in the recorded values of germination (%) and speed of germination (%) of the produced jute seeds due to different fertilizer treatments was statistically insignificant. However, dry weight of jute seedlings and vigour index varied significantly at the considered fertilizer doses (Table 2). N_{80} P_{40} K_{80}produced the highest seedling biomass (22.14

Table 4: Economics of *olitorius* jute seed growing in the southern Bengal condition (Pooled data of two years)

Treatments	Input cost (₹ ha^{-1})	Labour cost (₹ ha^{-1})	Total cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	NRPRI
T_1: No fertilizer	15,875	26,800	42,675	68,385	25,710	0.60
T_2: N_{80} (2 splits)	17,055	28,400	45,455	1,06,659	61,204	1.35
T_3: N_{80} (3 splits)	17,055	29,200	46,255	1,12,958	66,703	1.44
T_4: N_{80} (2 splits), P_{40}	19,055	28,400	47,455	1,17,733	70,278	1.48
T_5: N_{80} (2 splits), P_{40}	19,055	29,200	48,255	1,21,835	73,580	1.52
T_6: N_{80} (2 splits), P_{40}, K_{80}	21,382	28,400	49,782	1,28,094	78,312	1.57
T_7: N_{80} (3 splits), P_{40}, K_{80}	21,382	29,200	50,582	1,37,876	87,294	1.73

Note: One man day ₹ 200; Price of jute seed ₹ 125 per kg; NRPRI = Net Return Per Rupee Investment.



(a) PCA of the seed yield and related parameters **(b) PCA of the seed quality related parameters**

Fig. 1: PCA plots of seven nutrient management treatments for jute seed yield and yield parameters (a) and seed quality parameters (b).

mg per 20 seedlings) and the least seedling weight was recorded when no fertilizer applied (16.93 mg per 20 seedlings).The highest value of seedling vigour index was found in N_{80} P_{40} K_{80}treatment (2205) and the minimum vigour index value was recoded with no fertilizer treatment (1673). The quality parameters of *olitorius* jute seed obtained in this field experiment were at par with the prescribe quality parameters (Anon., 2013). Earlier studies reported that application of K and S produced bolder seeds in southern Bengal condition (Mondal *et al*., 2003; 2007). Bolder seeds produced from this field experiment retained in BSS 16 x 16 sieves and gave higher vigour index as reported earlier by Jerlin *et al*. (2010). Seed infection in the produced seed was not varied significantly due to different nutrient management treatments. In general, the seed infection was minimum (0.31 to 0.45%), well below the prescribed limit for quality jute seed (Sarkar *et al*., 2016).

Principal component analysis (PCA)

In this present field trial, PCA of different parameters related to jute seed yield and yield parameters [Fig. 1(a)] comprised of two principal components (PC1 and PC2) could able to explain 99.6% of the total variation. Whereas, PCA of related various parameters of jute seed quality [Fig. 1(b)] comprised of PC1 and PC1 explained 88.0% of total variation. High positive correlation between the jute seed yield and the corresponding values of the concerned yield parameters was detected in calculation. Similarly, in jute seed quality study also, high positive correlation was recorded among the concerned parameters, except the seed infection (%) which showed negative correlation with the seed quality parameters.

Effect on available primary soil nutrients

It was observed that N fertilization increased the available N status of the soil sample after jute seed crop harvest (Table 3). Positive N balance due to application of nitrogenous fertilizer was between 40.14 and 56.97 kg ha^{-1}. In case of phosphate also, P applied plots showed increased available P content and the measured range was 5.0 to 5.5 kg ha^{-1}. Similarly, in case of potassium, available K status was higher in the K applied treatments and the positive available K balance was about 27 kg ha^{-1}.

Agronomic efficiency

Agronomic efficiency (AE) significantly varied among the nutrient management treatments and the highest AE was 4.45, where only 80 kg N was applied in 3 splits. Among all the treatments, it was clearly recorded that application of N fertilizer in 3 splits resulted higher AE to the tune of 8.21% (between T_5 and T_4), 16.49% (between T_3 and T_2) and 16.81% (between T_7 and T_6) when compared with two splits of N fertilization (in T_4, T_2 and T_6).

Economics of jute seed production in southern Bengal condition

Seed production economics of *olitorius* jute in the fibre producing southern Bengal condition is given in Table 4. It was recorded that the total cost of cultivation of jute seed growing in southern Bengal condition varied between ₹ 42,675 to 50,582 depending on the nutrient management practices followed. It was recorded that, out of the total cost of cultivation of jute seed, 57-63% was for labour cost and the material input cost was 37-43%. In case of application of all the primary nutrients (N, P, K) with 3 split applications of nitrogenous fertilizer, the total cost of cultivation was ₹ 50,582 ha^{-1}. The net returns from the jute seed production activity varied from mere ₹ 25,710ha^{-1} to as high as ₹ 87,294 ha^{-1}. It was recorded that the highest net return per rupee investment (NRPRI) was 1.73, where 80 kg N (in 3 splits), 40 kg P_2O_5 and 80 kg K_2O ha^{-1} were applied. Field trial conducted in Maharashtra also found higher profitability from jute seed production (More and Pacharne, 2017).

CONCLUSION

From the findings of the two years field experiment, it is confirmed that by appropriately managing nutrients through application of N 80 kg, P_2O_5 40 kg, K_2O 80 kg ha^{-1}, where ½ of N applied at 21-28 DAS just after weeding and thinning operations; ¼ N applied at 42 DAS at the time of apical bud removal; and ¼ N applied at 56 DAS at active branching stage and by following other standard jute seed crop management practices, *olitorius* jute seed can be grown (during 1st September - 31stDecember) successfully in southern Bengal condition with 11.03 q ha^{-1} seed yield, better seed quality parameters such as 2.294 g of test weight, 99-100% germination, higher vigour index (>2200), and higher net return (± ₹ 87,000 ha^{-1}).

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