Precision Fertilization Strategies for Maximizing Jute Yield in Alluvial Soils of Seemanchal region of Bihar

ABSTRACT

This research explores precision fertilization techniques to enhance jute production in Katihar district, Bihar, crucial for small farming households in the Seemanchal region, aiming to replace indiscriminate nitrogen application with the Soil Test Targeted Yield (ST-TY) method, crucial for the economic and environmental value of jute, known as the "golden fiber." Over two years (2019-2020) in the Seemanchal region's Katihar district, an experiment compared Soil Test Targeted Yield (ST-TY) method with traditional practices, revealing minimal impact on soil properties but significant decreases in available nitrogen and phosphorus levels raising concern over nutrient management. Notably, achieving a targeted fiber yield of 32.52 qha-1 through specific fertilizer applications (83:35:19 N:P:K kg/ha) with organic matter consistently outperformed other methods. The method resulted in superior plant growth (385 cm) and fiber production (32.52 q ha-1), yielding the highest net income (96884 Rs ha-1) and benefit-cost ratio (3.44), showcasing its economic viability. This underscores the importance of tailored fertilizer strategies and organic materials for enhancing jute cultivation, suggesting broader adoption potential in Seemanchal and beyond.

Keywords: jute, STTY, Fertilization Strategies, Alluvial Soils

1. Introduction:

Jute is an important natural fiber crop of India, ranking next to cotton in significance. It holds a prestigious position in India's industrial and agricultural economy. The eastern Indian states of West Bengal, Assam, Bihar, Odisha, Meghalaya, and Tripura have well-established jute cultivation, which also plays an integral role in the lives of around 40 lakh small and marginal farm families in the region (Majumdar *et al.* 2019). Originally considered solely as a raw material for packaging industries, jute has now emerged as a versatile resource with diverse applications. Its uses extend to textile industries, paper industries, building and automotive sectors, as well as for soil conservation, decorative, and furnishing materials. Being biodegradable and an annually renewable source, jute is recognized as an environment-friendly crop, contributing to the maintenance of ecological balance. Over the last decade, the jute cultivation area in India has remained between 7.5 to 8.0 lakh hectares, with total jute production varying between 96.34 and 115.38 lakh bales. The evolution of newer jute varieties and improved agronomic management practices, including nutrient management, has reduced the crop duration from over 150 days in the early 1970s to 120 days or even lesser. The response of crop yield to nutrient application is influenced by nutrient requirements, availability from indigenous sources, and the fate of fertilizer application in the soil. The indiscriminate use of fertilizers without considering crop-specific nutrient requirements and soil nutrient availability can adversely affect both soil health and crop productivity (Ray *et al.* 2000). Given the increasing demand for chemical fertilizers and depleting soil fertility, a shift towards integrated organic and inorganic sources of nutrients is imperative for sustainable crop production.

The targeted yield approach, originally conceptualized by Ramamoorthy *et al.* (1967) and later modified by Kanwar (1971), offers a more effective alternative to general fertilizer recommendations. By applying soil testing and target yield-based fertilizer doses to crops, this approach ensures a greater response ratio and benefit-cost ratio. Nutrient imbalances in the soil can be rectified as nutrients are applied proportionally to address specific deficiencies. In light of the above, this study aims to evaluate the effectiveness of the Soil Test Targeted Yield (ST-TY) approach in jute cultivation within the Seemanchal area of eastern India. The research compares this approach with conventional farmer practices to assess its impact on soil properties, jute growth attributes, fiber yield, and economic viability. The findings of this study will contribute valuable insights to optimize nutrient management strategies for jute cultivation, leading to enhanced productivity and improved economic returns for jute farmers in the region.

2. MATERIALS AND METHODS:

The experiment was conducted in farmers' fields under the jurisdiction of Krishi Vigyan Kendra, Katihar, affiliated with Bihar Agriculture University, Sabour, Bhagalpur. The study spanned two consecutive years, 2019 and 2020, aiming to investigate the impact of soil test-based optimal fertilizer doses on achieving target jute yields in the alluvial soils of the Seemanchal region. The experimental site is positioned within Latitude 25'N to 26'N and Longitude 87' to 88'E, at an elevation of 32 meters above Mean Sea Level (MSL). The climate of the region is characterized as sub-tropical and humid, with an average temperature (Max. & Min.) of 42°C and 4°C, respectively, and an average annual rainfall of about 1298 mm.

2.1 Experimental site and soil analysis

The experimental soils were non-calcareous in nature belonging to the Alluvial Tract under Agro ecological zone-II lies between three major rivers Mahananda, Kosi and Ganga. The soil samples were collected from experimental plots before the experiment start on and after harvest jute crop. Both years soil samples from depths 0-15 cm were taken before sowing and after harvesting of jute crop from each plot at random using double cylinder core samplers with sample holder (inner cylinder) diameter and height of 50 mm high (Black and Hartge, 1986). The sampler was pressed vertically into the soil surface enough to fill the sampler, but not so far to compress the soil in the compound space of the sampler. The sampler and its contents were carefully removed to preserve the natural structure and packing of the soil as best as possible. The two cylinders were sorted, retaining the undisturbed soil in the inner cylinder. The soil extending beyond each end of the sample holder was trimmed to flush with a straight edged knife. The soil sample volume was thus established to be the same as the volume of the sampler holder. The soil cores were wrapped in paper, transported and safely stored in the laboratory safely. Air-dry the soil sample in shade for chemical analysis. Crush the soil and grind with the help of grinder and pass through 0.2 to 0.5 mm sieves before analysis and record. Bulk density (B.D.) of soil was determined by core sampler method (Bodman, 1942), Particle density by Pycnometer method and porosity determined with the help of formula based on BD and PD (Chopra and Kanwar, 1991). Organic carbon content was determined by the Walkley and Black method (1934). Available nitrogen was determined by the alkaline $KMNO_4$ method (Subbaiah and Asija, 1956), and available phosphorous (Olsen's method, 1954) and available potash were determined Flamphotometrically method (Tandon, 1993). The EC and pH of soil were estimated after preparing 1:2 soil water suspension by conducto-metrically and electro metrically using glass electrode methods (Piper, 1996), respectively.

The experiment was design in RBD with three treatments [(T_1 – FP (23:20:15 :: N:P:K kg ha^{-1}), T_2 – ST-TY (35 qha^{-1}) = 123:49:27:: N:P:K kg ha^{-1} and T_3 - ST-TY (35 qha^{-1}) = 83:35:19:: N:P:K kg ha^{-1} + FYM @ 5 t ha^{-1})] and ten replications. The unit plot size was 10.0 m X 10.0 m. and ten replications. The land was prepared in early April and manures & fertilizers applied as par recommendation of STCR based nutrients recommendation. All the fertilizers were applied as per treatments dose in each individual plot during the final land preparation and rest nitrogenous fertilizer were applied at different stages recommended in different treatments. Jute seed var JRO 204 in plot was sown on 12th and 14th April 2019 at the rate of 5 kg ha^{-1} with 20 cm row to row and 5 cm plant to plant spacing. After sowing, water the jute crop for the first time, and then again on the fourth day. After that, water the crop every 15 days and weeding with thinning was there at 25 DAS. The growth and yield parameters of individual plant were recorded of 10 plants in each plot. A total of five harvests (5 plants / replication / harvest) were received for recording data on some morpho-physiological attributes of jute by oven dry method. The first crop sampling was done at 30 days after sowing and subsequently at 10 days interval upto 100 DAS. The plants were separated into roots stems and leaves and the corresponding green weights were recorded after that created environment for retting. Retting is a microbiological process in which the jute bundles are submerged in soft, clean water for 15 days. It loosens the outer bark and help in removal of the fiber from the stalk. Other morpho-physiological attributes of jute were also calculated by respective method. The following growth parameters were also computed using the formula given by Hunt (1978).

2.2 Statistical analysis:

The data collected on different parameters under the experiment were statistically analyzed to obtain the level of significance using the computer MSTAT package program developed by Russel (1986). The differences between pairs of means were compared by Duncan's multiple range test (DMRT) as stated by Gomez and Gomez (1984).

3. Result and discussion:

The data related to soil is presented in table 1. It is clear from the table that the initial pH of the soil was 5.89, which slightly decreased to 5.87 by the end of the experiment This small change in pH is not statistically significant (NS), suggesting that the treatment did not have a substantial impact on soil pH. Like pH, ECe this change is also statistically nonsignificant (NS), indicating that the treatment did not significantly affect the soil's electrical conductivity. Organic carbon content in the soil increased from 0.58% initially to 0.60% after the experiment. This minor increase is statistically nonsignificant (NS), suggesting that the treatment did not lead to a significant change in organic carbon levels. The concentrations of available nutrients (N, P, K) in the soil were evaluated in kg ha^{-1}. After the experiment, the available nitrogen (N) content decreased from 324 kg ha^{-1} to 305 kg ha^{-1}, which is a statistically significant change. Similarly, available phosphorus (P) decreased from 31 $kgha^{-1}$ to 28 kg ha^{-1}, which is also statistically significant. Available potassium (K) decreased from 245 kg ha^{-1} to 235 kg ha^{-1}; however, this change is not statistically significant.

The treatment applied in this study had a limited impact on the soil's physico-chemical properties, with minor changes observed in organic carbon content. However, the significant decrease in available nitrogen and phosphorus levels raises questions about nutrient management practices and their effects on crop performance, warranting further research and consideration in future agricultural practices. These findings are conformity by Ray *et al.* (2000), Doharey *et al.* (1980), Ray and Gupta (1979), Majumdar *et al.* (2014).

3.1 Yield Attributes and yield:

It is evident from Table 2 that the yield attributing characteristics of jute (*Corchorus olitorius*) are influenced by different treatments, encompassing plant height (cm), basal diameter (cm), green weight of plant (q ha^-1), fiber yield (q ha^-1), and the deviation from the targeted yield (%) for each treatment. Plant height varied significantly among the treatments. Treatment T_3 resulted in the tallest plants with an average height of 385 cm, followed by T_2 with 372 cm, and T_1 with 292 cm. The critical difference (CD) for plant height indicated that these differences are statistically significant between different treatments. The taller plants in T_2 and T_3 suggest that these treatments might have provided conditions more conducive to vertical growth.

Similarly, basal diameter, akin to plant height, exhibited significant variation among the treatments. T_3 had the largest basal diameter at 1.96 cm, followed by T_2 at 1.88 cm, and T_1 at 1.38 cm. The critical difference for basal diameter indicated that these differences are statistically significant with each treatment. A larger basal diameter typically indicates sturdier and healthier plants.

Furthermore, the green weight of the jute plants also differed significantly among the treatments. T_3 had the highest green weight at 412.71 q ha^-1, followed by T_2 at 381.27 q ha^-1, and T_1 at 246.37 q ha^-1. It is evident from the data that these differences are statistically significant. A higher green weight suggests more vigorous plant growth and biomass accumulation.

Regarding fiber yield, a crucial measure for jute cultivation, significant variations were observed among the treatments. T3 yielded the highest fiber yield at 32.52 q ha^-1, followed by T_2 at 30.26 q ha^-1, and T_1 at 19.38 q ha^-1. The CD for fiber yield signified that these differences are statistically significant between each treatment. The higher fiber yield in T_2 and T_3 indicates the effectiveness of these treatments in promoting jute fiber production.

Targeted yield deviation represents the percentage deviation from the expected or targeted yield. T_1 had the highest deviation from the targeted yield at 44.63%, followed by T_2 at 13.54%, and T_3 at 7.09%. These differences are statistically significant, and a lower deviation percentage suggests that T_3 achieved a yield closer to the targeted yield.

Overall, these results underscore the significant influence of different treatments on the yield attributing characters of jute. Treatment T_3 consistently outperformed the other treatments in terms of plant height, basal diameter, green weight of plants, and fiber yield. This indicates that T_3, which involved specific fertilizer doses and the application of organic matter (FYM), was the most effective in promoting jute growth and fiber production. These findings emphasize the importance of tailored fertilizer treatments, including the addition of organic matter, in optimizing jute cultivation. Treatments T_2 and T_3 show promise for improving jute yields, with T_3 being particularly noteworthy for its comprehensive positive impact on jute growth and fiber yield. These results are in line with the findings of Ray *et al.* (2000), Kumar *et al*. (2016), Ray and Gupta (1979), and Majumdar *et al*. (2014).

3.2 Economics:

Net income represents the profit obtained from jute cultivation after deducting the cost of cultivation from the gross income (table 3 & fig 2). T_3 - ST-TY (35 qha^{-1}) = 83:35:19 kg ha^{-1}:: N:P:K + FYM @ 5 t ha^{-1}) yielded the highest net income at Rs 96,884 per hectare, followed by T_2 – ST-TY (35 qha^{-1}) = 123:49:27 kg ha^{-1}:: N:P:K at Rs 89,692 per hectare, and T_1 – FP (23:20:15 kg ha^{-1} :: N:P:K) at Rs 44,896 per hectare. The CD for net income was 41.07 Rs ha^{-1}, indicating statistically significant differences. The B:C ratio is a critical economic indicator that assesses the profitability of an agricultural venture. T_3 had the highest B:C ratio at 3.44, followed by T_2 at 3.40, and T_1 at 2.23. The CD for the B:C ratio was 0.06, signifying statistically significant differences between different treatments.

The economic analysis indicates that T_3, despite its higher cultivation cost, resulted in the highest gross and net income and the most favorable B:C ratio. This suggests that T_3 not only promotes better jute growth and fiber yield (as shown in Table 2 & fig 1) but is also economically superior to the other treatments. T_2 –123:49:27 kg ha^{-1}:: N:P:K also performed well economically, but T_3 - 83:35:19 kg ha^{-1}:: N:P:K + FYM @ 5 t ha^{-1}appears to be the most economically viable treatment for jute cultivation. These findings also conformity with the findings of Kumar *et al.* (2016), and emphasize the importance of optimizing fertilizer and nutrient management practices for maximizing both crop yield and profitability in jute farming.

The studies collectively emphasize the significance of precise nutrient management, tailored fertilizer application, and the inclusion of organic matter for maximizing jute yield and profitability in the Seemanchal region. The incorporation of precise nutrient management practices, informed by soil testing and tailored fertilizer application, can serve as a model for optimizing agricultural productivity in similar agroecological zones. By focusing on both agronomic practices and economic sustainability, STTY studies provide a holistic framework for enhancing jute cultivation practices in Seemanchal and potentially beyond. T_3 stands out as the most promising treatment in terms of both crop productivity and economic returns, suggesting its potential for wider adoption in jute cultivation practices.

CONCLUSION:

The study investigated various treatments' influence on jute yield attributes, revealing significant variations in plant height, basal diameter, green weight, fiber yield, and targeted yield deviation. Treatment T_3 consistently outperformed others, indicating its effectiveness in promoting jute growth and fiber production. Economically, T_3 yielded the highest net income and the most favorable benefit-to-cost ratio, emphasizing its viability for jute cultivation. Tailored fertilizer treatments, including organic matter, are crucial for maximizing yield and profitability. Overall, T_3 emerges as the most promising option for enhancing both productivity and economic returns in jute cultivation, suggesting its potential for wider adoption. Further research should focus on optimizing treatment parameters and assessing long-term sustainability.

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Table 1: Physico-chemical Properties of experimental Soil (pooled data)

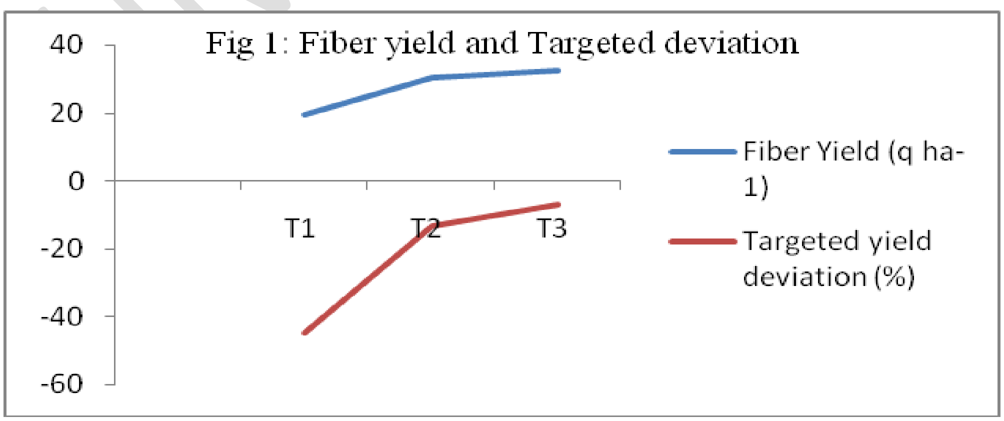
Treatments	pH (1:2.5)	ECe (dSm^{-1})	O.C. (%)	Available Nutrients (kg ha^{-1})		
				N	P	K
Initial	5.89	0.17	0.58	324	31	245
Final	5.87	0.18	0.60	305	28	235
CD (p=0.05)	NS	NS	NS	2.45	0.47	2.7

Table 2: Yield attributing characters of Jute (*Corchorous olitorius*) (pooled data)

Treatments	**Plant height (cm)**	**Basal diameter (cm)**	**Green weight of Plant ($q\ ha^{-1}$)**	**Fiber Yield ($q\ ha^{-1}$)**	**Targeted yield deviation (%)**
T_1	292	1.38	246.37	19.38	44.63
T_2	372	1.88	381.27	30.26	13.54
T_3	385	1.96	412.71	32.52	7.09
CD (p=0.05)	7.01	0.23	2.36	1.02	1.86

Table 3: Economics of Jute (*Corchorous olitorius*) (pooled data)

Treatments	Cost of cultivation ($Rs\ ha^{-1}$)	Gross income ($Rs\ ha^{-1}$)	Net Income ($Rs\ ha^{-1}$)	B:C ratio
T_1	36500	81396	44896	2.23
T_2	37400	127092	89692	3.40
T_3	39700	136584	96884	3.44
CD (p=0.05)	26.07	85.36	41.07	0.06



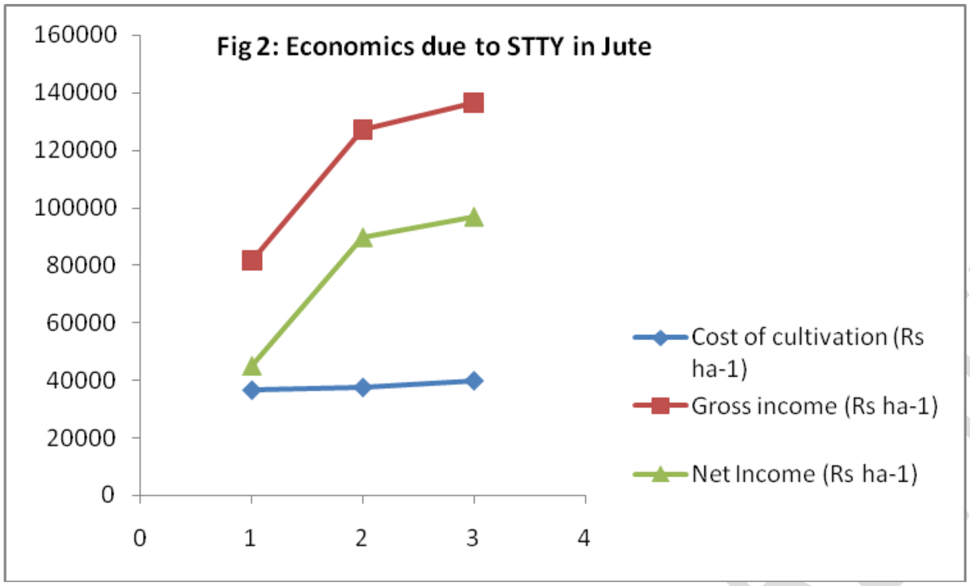


Fig 2: Economics due to STTY in Jute
160000
140000
120000
100000
80000
60000
40000
20000
0
0
1
2
3
4
Cost of cultivation (Rs ha-1)
Gross income (Rs ha-1)
Net Income (Rs ha-1)