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Performance of Jute-Based Cropping Systems under Mung Bean and Cowpea Intercropping in Rainfed Conditions

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ABSTRACT

Jute productivity in South Asia faces challenges due to declining soil fertility, heavy weed problems, and increasing production costs. Legume intercropping provides a sustainable approach by improving nutrient availability, controlling weeds, and increasing overall productivity. This three-year field experiment from 2022 to 2024 was conducted at the Jute Research Program in Itahari, Nepal. It aimed to evaluate the impact of mung bean and cowpea intercropping on the growth, fiber yield, and economic returns of three tossa jute varieties: Itahari-4, JRO-204, and NJ-7010. The experiment used a split-plot design with legumes planted between jute rows. Intercropping notably affected most growth and yield parameters, while the differences among varieties were mostly insignificant. Cowpea (Malepatan-1) and mung bean (Local) enhanced plant height, basal diameter, and biomass production compared to sole cropping. In combined analysis, the highest green plant yield (58.79 t ha^{-1}), green fiber yield (21.63 t ha^{-1}), and dry fiber yield (3.90 t ha^{-1}) were found in jute + cowpea (Malepatan-1), showing increases of 35% to 60% over sole cropping. The intercrop yield equivalent to jute fiber reached 1.0 to 1.56 t ha^{-1}, making a significant contribution to total productivity. The Jute Fiber Equivalent Yield (JFEY) was highest in jute + cowpea (Malepatan-1) at 5.40 t ha^{-1}, more than double the yield from sole cropping. Economic analysis showed net returns up to Rs. 520,391 ha^{-1} for jute + cowpea (Malepatan-1) compared to Rs. 248,500 ha^{-1} for sole jute. Overall, cowpea (Malepatan-1) proved to be the most compatible intercrop, offering substantial yield and economic benefits across jute varieties. The findings confirm that intercropping with legumes, especially cowpea, greatly improves productivity, profitability, and sustainability in jute farming systems in Nepal.

Keywords: Cowpea, Intercropping, Jute, cropping system, Mung bean

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INTRODUCTION

Jute (*Corchorus olitorius* and *C. capsularis*) ranks among the most important bast fiber crops globally, primarily grown in South Asia due to its significant economic, industrial, and environmental roles. It is a key income source for millions of smallholder farmers in Bangladesh, India, and Nepal, making it essential for rural livelihoods and agro-based businesses (Albugami et al 2025). However, jute production encounters several agronomic challenges, including declining soil fertility, severe weed infestations during early growth stages, inadequate nutrient management, and rising cultivation costs (Srivastava et al 2025). These issues often result in low fiber yields and reduced profitability, highlighting the need for sustainable and efficient farming practices.

Intercropping, which involves growing two or more crops simultaneously on the same land, is widely seen as an effective agroecological strategy to enhance resource use efficiency, improve soil health, and boost overall productivity (Lithourgidis et al 2011). It also helps control weeds naturally by limiting their establishment. Leguminous intercrops can significantly suppress weed growth by competing for light, nutrients, and moisture (Jhade et al 2018). Additionally, legumes improve soil structure, organic matter, and microbial activity, which supports the long-term health and sustainability of jute-based systems (Singh and Shivay 2019). As interest grows in low-input and climate-resilient agriculture, adding legume intercropping into jute farming is seen as a promising way to increase fiber yield, resource efficiency, and environmental sustainability. In jute-based systems, the slow initial growth and wider spacing permit compatible intercrops to flourish without harming fiber yield (Afrose 2014).

Legumes, in particular, offer notable benefits since they fix biological nitrogen, enhance soil organic matter, and promote system sustainability (Peoples et al 2009). Previous researches shows that incorporating short-duration legumes like mung bean, cowpea, black gram, or soybean in jute cropping can reduce weed biomass, improve soil nutrient levels, and boost overall land productivity (Mondal et al 2014, Prasad et al 2019). However, integrating these legumes into existing jute systems remains under-researched, revealing a significant knowledge gap. There is a lack of location-specific, empirical data comparing the agronomic performance, system productivity, and economic viability of jute-legume intercropping under the rainfed conditions typical of much of Koshi Province.

To address this gap, this study introduces a new cropping configuration aimed at transforming the current jute monoculture. The key innovation in this research is the direct comparison of jute intercropped with mung bean against cowpea as a new model for sustainable intensification. We propose that intercropping will significantly improve overall productivity and economic returns compared to jute monoculture, with performance likely differing between the two legume species. This study aims to (i) evaluate the agronomic performance of jute intercropped with mung bean and cowpea, (ii) determine total system productivity through the Land Equivalent Ratio (LER), and (iii) assess the economic viability of these jute-legume intercropping systems within the rainfed agro-ecosystem of Koshi Province. The results should provide evidence-based recommendations for diversifying and strengthening the resilience of traditional jute farming practices.

MATERIALS AND METHODS

Experimental Site and Duration

Field experiments were conducted during the rainy seasons of 2022, 2023, and 2024 at the Jute Research Program's farm in Itahari, Nepal. The location is approximately 26°66’46” N latitude and 87°27’18” E longitude, at about 130 meters above sea level. The region has a humid subtropical monsoon climate, with high temperatures (averaging 28–32°C) and significant rainfall (over 2000 mm annually) during the growing season (May to September), making it ideal for jute cultivation. The experimental field's soil was sandy loam (Typic Haplustept), with baseline properties assessed before planting. Soil fertility analysis showed moderately acidic soils (pH ~6.2) with medium organic matter (~1.6%), moderate total nitrogen (~0.09%), low available phosphorus (~4.5 kg/ha), and medium available potassium (~120 mg/kg) in the top 0–15 cm layer

Experimental Design and Treatments

The study employed a split-plot design replicated three times to evaluate the effects of different cropping systems on jute performance. Three tossa jute varieties: Itahari-4, JRO-204, and NJ-7010 (Rani) were assigned to the main plots. Four intercropping systems: Jute + Mung bean (Local), Jute + Mung bean (Pratikshya), Jute + Cowpea (Malepatan-1), Jute + Cowpea (Sarlahi Tane) alongside one Jute sole crop (control) were allocated to sub-plots, resulting in 15 treatment combinations.

Crop Establishment and Management

Seeds of the intercrops were planted in rows spaced 40 cm apart, while jute seeds were sown 20 cm apart, positioned centrally between the intercrop rows (10 cm from each adjacent intercrop row). All crops were planted in the first week of May each year and harvested in the second week of September. Thinning occurred 10 to 15 days after sowing (DAS) to maintain uniform intra-row spacing of 5 to 7 cm for jute. A uniform basal dose of chemical fertilizer was applied at a rate of 40:20:40 kg/ha of N: P_2O_5: K_2O. Recommended plant protection measures (for insect and weed control) and other necessary intercultural operations were carried out throughout the growing season to promote healthy crop growth.

Data Collection

Intercrop harvesting was timed based on maturity. A sample was harvested from a central area of 4 m² within each plot for data collection. The following agronomic and yield-related parameters were recorded:

Growth Parameters: Plant height (cm) and basal diameter (cm) at harvest.

Yield Parameters: Green plant yield (t ha^{-1}), green fiber yield (t ha^{-1}), green stick yield (t ha^{-1}), dry fiber yield (t ha^{-1}), and dry stick yield (t ha^{-1}).

System Productivity: Jute equivalent yield of the intercrops (t ha^{-1}).

Economic Analysis: Net returns (Rs. ha^{-1}) from the jute + intercrop system were calculated based on current market prices for jute fiber and the respective intercrops, factoring in cultivation costs:

Statistical Analysis

All collected data were analyzed using variance analysis (ANOVA) suitable for a split-plot design with STAR 2.0 (Statistical Tool for Agricultural Research) software. Treatment means were compared using the Least Significant Difference (LSD) test at a 5% probability level ($p \leq 0.05$) to identify significant differences among treatments.

RESULTS

Effect on jute plant height

The analysis of variance for plant height indicated no significant differences among jute varieties in any individual year or in the combined analysis. However, the overall effect of intercrop treatment and the interaction between variety and intercrop were statistically significant in 2022, 2023, and the combined analysis. In 2024, plant height wasn't significantly impacted by any factor. In both 2022 and 2023, the treatment of jute intercropped with local mung bean showed the highest plant height (310.1 cm and 307.6 cm, respectively), whereas jute + Sarlahi Tane cowpea yielded the shortest plants (270.0 cm and 268.0 cm, respectively) (Table 1). Notable variety × intercrop interactions were also recorded. For example, in the jute + Malepatan-1 cowpea intercrop (2022), Itahari-4 reached the tallest plants (303.0 cm), while JRO-204 produced the shortest (287.7 cm). Conversely, in the jute + Sarlahi Tane cowpea intercrop (2022), NJ-7010 Rani had the tallest plants (275.6 cm), and again, JRO-204 recorded the shortest (266.8 cm) (Table 1).

Table 1. Effect of jute + legumes intercropping practices on jute plant height (cm) at JRP, Itahari

Treatments	2022				2023				2024				Combined			
	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean
Jute + Malepatan 1	303.0	287.7	293.9	294.8	301.0	295.0	295.2	297.0	328.6	338.7	346.2	337.8	310.8	307.1	311.5	309.9
Jute + Sarlai Bodi	267.5	266.8	275.6	270.0	265.5	264.8	273.6	268.0	354.0	343.1	336.5	344.5	295.7	291.5	295.2	294.1
Jute + Mung local	320.0	303.6	306.7	310.1	317.9	300.3	304.7	307.6	345.4	356.1	331.9	344.4	327.7	319.9	314.4	320.7
Jute + Mung Pratishya	284.1	290.3	307.0	293.8	282.1	288.3	305.0	291.8	327.9	353.6	350.6	344.1	298.1	310.7	320.9	309.9
Jute Sole crop	297.1	307.9	269.8	291.6	295.1	305.9	267.8	289.6	449.9	444.5	316.5	403.7	347.4	352.7	284.7	328.2
Mean	294.3	291.3	290.6	292.1	292.3	290.9	289.3	290.8	361.2	367.2	336.4	354.9	315.9	316.4	305.4	312.5
F-Value (Variety)				Ns				ns				Ns				ns
LSD (0.05)				-				-				-				-
F-Value (Treatment)				**				**				Ns				*
LSD (0.05)				7.85				8.85				-				10.85
F-Value (Var x Trt)				**				**				Ns				*
LSD (0.05)				13.6				15.32				-				12.37
CV (%)				2.8				3.2				19.1				8.37

*=Significant at P ≤ 0.05. **=P≤0.01. LSD=Least significant difference. CV= coefficient of variantion respectively. V1= Itahari-4, V2= JRO-204, V3= NJ-7010 (Rani).

The combined analysis across all years indicated that sole-cropped jute had the highest average plant height (328.2 cm), significantly outperforming all intercrop treatments. The shortest plants in the combined analysis were again from the jute + Sarlahi Tane cowpea intercrop (294.1 cm). The highest plant height recorded throughout the study was for the JRO-204 variety under sole cropping (352.7 cm), while the same variety showed the shortest (291.5 cm) when intercropped with Sarlahi Tane cowpea (Table 1).

Effect on jute basal diameter

The basal diameter of jute was notably affected by the cropping system, but the genetic variety didn't play a significant role. The variety's influence was deemed non-significant over the individual years from 2022 to 2024, as well as in the overall analysis. On the flip side, the intercrop treatment had a significant impact each year and when combined (Table 2). There was an observed interaction between variety and intercrop in 2022 and 2023, although it was non-significant in 2024 and in the combined review. This suggests that the effects of intercropping were consistent throughout the study period. In 2022, using intercropping resulted in a noticeable increase in basal diameter compared to sole cropping. The highest average diameter (1.67 cm) was recorded in the jute and local mung bean combination, while the smallest diameter (1.35 cm) came from sole jute. Within the significant interaction, the variety NJ-7010 (Rani) intercropped with Malepatan-1 cowpea achieved the largest diameter (1.81 cm) (Table 2). In 2023, the jute and Malepatan-1 cowpea intercrop had an average diameter of 1.53 cm, again larger than sole jute, which measured just 1.20 cm. The interaction indicated that NJ-7010 (Rani), when intercropped with cowpea, reached its peak diameter of 1.69 cm, while the same variety alone only produced 1.04 cm (Table 2). By 2024, only the main effect of the intercrop remained significant. The jute and Malepatan-1 cowpea treatment continued to show the largest diameter (1.65 cm), with sole jute being the smallest at 1.44 cm (Table 2). The overall analysis confirmed no variety effect but highlighted the strong, consistent benefits of intercropping. The largest average basal diameters were found in the jute and Malepatan-1 cowpea as well as the jute and local mung bean systems (1.57 cm each), both significantly greater compared to sole-cropped jute (1.33 cm) (Table 2).

Table 2. Effect of jute + legumes intercropping practices on jute basal diameter (cm) at JRP, Itahari

Treatments	2022				2023				2024				Combine			
	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean
Jute + Malepatan 1	1.59	1.35	1.81	1.58	1.58	1.3	1.69	1.53	1.5	1.57	1.74	1.65	1.56	1.42	1.75	1.57
Jute + Sarlai tane	1.55	1.50	1.49	1.51	1.53	1.3	1.34	1.41	1.59	1.55	1.57	1.57	1.56	1.47	1.47	1.50
Jute + Mung local	1.81	1.47	1.74	1.67	1.66	1.2	1.59	1.50	1.45	1.61	1.55	1.54	1.64	1.44	1.63	1.57
Jute + Mung Pratikshya	1.41	1.62	1.50	1.51	1.26	1.4	1.35	1.36	1.53	1.58	1.85	1.65	1.40	1.56	1.57	1.51
Jute Sole crop	1.35	1.52	1.19	1.35	1.20	1.3	1.04	1.20	1.51	1.47	1.35	1.44	1.35	1.45	1.19	1.33
Mean	1.54	1.49	1.55	1.53	1.45	1.3	1.4	1.4	1.52	1.56	1.61	1.56	1.50	1.47	1.52	1.50
F-Value (Variety)				ns				Ns				Ns				ns
LSD (0.05)				-				-				-				-
F-Value (Treatment)				**				**				*				*
LSD (0.05)				0.16				0.16				0.14				0.15
F-Value (Var × Trt)				**				*				Ns				ns
LSD (0.05)				0.21				0.28				-				-
CV (%)				9.4				12.1				9.4				10.23

*= Significant at P ≤ 0.05. **= P≤0.01. LSD= Least significant difference. CV= coefficient of variantionV1= Itahari-4, V2= JRO-204, V3= NJ-7010 (Rani).

Effect on jute green plant yield

The green plant yield, which is a key measure of biomass production, showed a more complex relationship with various factors compared to basal diameter. The main effect of jute variety was non-significant across all years and in the overall analysis. However, both the intercrop treatment and the interaction between variety and intercrop treatment were statistically significant each year and in the pooled data (Table 3). This means the yield response to intercropping varied based on the specific jute variety. In both 2022 and 2023, a clear trend emerged: the jute and Malepatan-1 cowpea intercrop system yielded the highest average outputs of 48.68 t ha^{-1} and 46.74 t ha^{-1}, respectively, while sole-cropped jute produced the lowest outputs (28.69 t ha^{-1} and 26.19 t ha^{-1}). The significant interactions highlighted a particular detail: the variety Itahari-4 achieved its peak yield when intercropped with local mung bean, reaching 57.63 t ha^{-1} and 55.13 t ha^{-1} in 2022 and 2023, respectively. In contrast, NJ-7010 (Rani) under sole cropping recorded the lowest yields of 27.72 t ha^{-1} and 25.22 t ha^{-1} in those years (Table 3). By 2024, yields increased considerably, likely due to favorable seasonal conditions, and the jute and Malepatan-1 cowpea system again yielded the highest average (80.96 t ha^{-1}), while sole cropping was the lowest (58.17 t ha^{-1}). The interactions showed that the combination of Itahari-4 with Malepatan-1 cowpea was optimal, producing the highest yield of 88.49 t ha^{-1}, whereas JRO-204 under sole cropping yielded the least at 51.61 t ha^{-1} (Table 3). Over the three years, the combined analysis reinforced the strength of these effects. The jute and Malepatan-1 cowpea intercrop achieved the greatest mean yield of 58.79 t ha^{-1}—56% higher than the yield from sole-cropped jute (37.68 t ha^{-1}). The ongoing, significant interactions between variety and intercrop treatment highlighted that Itahari-4 was particularly well-suited for intercropping, showing its highest combined yield (62.82 t ha⁻¹) with local mung bean, while the same variety faced the largest decline under sole cropping (35.71 t ha⁻¹) (Table 3).

Table 3. Effect of jute + legumes intercropping practices on jute green plant yield (t ha^{-1}) at JRP, Itahari

Treatment	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean
Jute + Malepatan 1	41.24	49.87	54.94	48.68	39.08	48.37	52.78	46.74	88.49	71.79	82.59	80.96	56.27	56.68	63.44	58.79
Jute + Sarlai tane	34.25	37.46	34.6	35.44	31.42	35.96	32.43	33.27	81.93	71.34	67.37	73.55	49.2	48.25	44.8	47.42
Jute + Mung local	57.63	44.33	42.58	48.18	55.13	42.17	39.42	45.57	75.71	71.02	75.4	74.04	62.82	52.51	52.47	55.93
Jute + Mung Pratikshya	42.76	45.65	47.7	45.37	40.26	43.15	45.53	42.98	69.2	64.07	61.49	64.92	50.74	50.96	51.57	51.09
Jute Sole crop	28.84	29.5	27.72	28.69	26.34	27	25.22	26.19	51.94	51.61	70.94	58.17	35.71	36.04	41.29	37.68
Mean	40.95	41.36	41.51	41.27	38.45	39.33	39.08	38.95	73.46	65.97	71.56	70.33	50.95	48.89	50.72	50.18
F-Value (Variety)				ns				ns				ns				ns
LSD (0.05)				-				-				-				-
F-Value (Treatment)				**				**				*				*
LSD (0.05)				1.66				0.16				6.11				6.11
F-Value (Var × Trt)				**				*				*				*
LSD (0.05)				2.87				0.28				10.59				10.59
C.V (%)				4.2				12.1				23.3				10.33

*= Significant at P ≤ 0.05. **= P≤0.01. LSD= Least significant difference. CV= coefficient of variantionV1= Itahari-4, V2= JRO-204, V3= NJ-7010 (Rani)

Effect on jute green fiber yield

the green fiber yield, which is the main economic product, revealed highly significant treatment effects. In both 2022 and 2023, the primary effects of variety, intercrop, and their interaction were all significant. However, in 2024, the variety main effect was non-significant, although the intercrop effect and the variety × intercrop interaction remained significant. The combined analysis showed no significant differences among varieties but confirmed significant effects from the intercrop and the interactions. Varietal Performance: In the years where varietal effects were significant, NJ-7010 (Rani) showed the best potential for fiber yield, hitting the highest averages of 14.86 t ha⁻¹ (2022) and 16.51 t ha⁻¹ (2023). In 2022, Itahari-4 had the lowest average yield at 13.84 t ha⁻¹ (Table 4). Intercrop Main Effect: The intercrop treatment had a strong and consistent influence on fiber yield. In 2022 and 2023, the jute and local mung bean system produced the most fiber (16.71 t ha⁻¹ and 18.47 t ha⁻¹, respectively), significantly outperforming sole-cropped jute (10.11 t ha⁻¹ and 11.76 t ha⁻¹). This pattern shifted in 2024, when the jute and Malepatan-1 cowpea intercrop yielded the highest at 30.07 t ha⁻¹, surpassing sole jute, which produced 21.99 t ha⁻¹. The combined analysis confirmed the jute and Malepatan-1 cowpea system as the top performer, yielding 21.63 t ha⁻¹, compared to 14.62 t ha⁻¹ from sole cropping (Table 4). Variety × Intercrop Interaction: Significant interactions across all analyses pointed to specific compatible combinations. The highest yield in the study (33.47 t ha⁻¹) was achieved by NJ-7010 (Rani) in the jute and Malepatan-1 cowpea system in 2024. This combination also produced the top yields within the interactions for 2022 (19.37 t ha⁻¹) and 2023 (21.02 t ha⁻¹), resulting in the highest mean (24.62 t ha⁻¹) in the combined analysis. On the other hand, the lowest yields consistently came from sole cropping: NJ-7010 (Rani) in 2022 (8.82 t ha⁻¹) and 2023 (10.47 t ha⁻¹), and JRO-204 in 2024 (18.89 t ha⁻¹) and in the combined analysis (13.49 t ha⁻¹) (Table 4).

Table 4. Effect of jute + legumes intercropping practices on jute green fiber yield (t ha^{-1}) at JRP, Itahari

Treatments	2022				2023				2024				Combined			
	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean
Jute + Malepatan 1	13.24	16.63	19.37	16.41	15.23	18.95	21.02	18.4	29.22	27.52	33.47	30.07	19.23	21.03	24.62	21.63
Jute + Sarlai tane	12.63	12.97	12.11	12.57	14.28	14.62	13.76	14.22	33.18	29.17	27.07	29.8	20.03	18.92	17.65	18.86
Jute + Mung local	18.5	15.38	16.26	16.71	20.48	17.03	17.91	18.47	30.11	28.93	26.94	28.66	23.03	20.45	20.37	21.28
Jute + Mung Pratikshya	13.23	14.59	17.74	15.19	15.22	16.24	19.39	16.95	27.2	22.91	26.36	25.49	18.55	17.91	21.16	19.21
Jute Sole crop	11.57	9.96	8.82	10.11	13.22	11.61	10.47	11.76	20.5	18.89	26.59	21.99	15.1	13.49	15.29	14.62
Mean	13.84	13.9	14.86	14.2	15.69	15.69	16.51	15.96	28.04	25.48	28.08	27.2	19.19	18.36	19.82	19.12
F-Value (Variety)				**				*				Ns				ns
LSD (0.05)				0.66				0.76				-				-
F-Value (Treatment)				**				**				*				*
LSD (0.05)				0.86				0.98				14.81				2.65
F-Value (Var × Trt)				**				**				*				*
LSD (0.05)				1.49				1.69				25.65				4.59
C.V (%)				6.3				6.4				21.6				12

*= Significant at P ≤ 0.05. **= P≤0.01. LSD= Least significant difference. CV= coefficient of variantionV1= Itahari-4, V2= JRO-204, V3= NJ-7010 (Rani)

Effect on jute green stick yield

The analysis of green stick yield, which is a critical byproduct and an indicator of total structural biomass, revealed a significant interplay of treatments similar to fiber yield. In 2022, the main effects of variety, intercrop, and their interaction were all highly significant. By 2023, the varietal main effect became non-significant, but intercrop and interaction effects remained highly significant. In 2024 and the combined analysis, varietal differences were again non-significant, yet the intercrop effect and variety × intercrop interaction continued to be significant. Varietal Performance: A significant varietal effect was noted only in 2022, with NJ-7010 (Rani) producing the highest average stick yield (17.89 t ha^{-1}), while JRO-204 had the lowest yield (17.00 t ha^{-1}) (Table 5).

Table 5. Effect of jute + legumes intercropping practices on jute green stick yield (t ha^{-1}) at JRP, Itahari

Treatments	2022				2023				2024				Combine			
	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean
Jute + Malepatan 1	15.93	19.7	23.52	19.72	16.81	21.25	24.4	20.82	39.59	32.32	40.0	37.3	24.11	24.42	29.31	25.95
Jute + Sarlai tane	15.35	16.91	14.63	15.63	16.23	17.79	15.51	16.51	39.37	32.42	30.53	34.11	23.65	22.37	20.22	22.08
Jute + Mung local	23.04	19.42	18.12	20.19	23.92	20.3	19	21.07	34.74	32.57	33.18	33.5	27.23	24.10	23.43	24.92
Jute + Mung Pratikshya	16.93	17.73	20.89	18.52	17.81	18.61	21.77	19.4	33.19	26.08	29.51	29.59	22.64	20.81	24.06	22.50
Jute Sole crop	14.51	11.23	12.28	12.67	15.39	12.11	13.16	13.55	23.6	22.69	31.96	26.08	17.83	15.34	19.13	17.43
Mean	17.15	17.0	17.89	17.35	18.03	18.01	18.77	18.27	34.1	29.22	33.04	32.12	23.09	21.41	23.23	22.58
F-Value (Variety)				*				ns				ns				ns
LSD (0.05)				0.76								-				-
F-Value (Treatment)				**				**				*				*
LSD (0.05)				0.98				0.94				6.5				2.81
F-Value (Var x Trt)				**				**				*	*			*
LSD (0.05)				1.69				1.63				11.25				4.86
C.V (%)				5.9				5.3				20.9				10.70

*= Significant at P ≤ 0.05. **= P≤0.01. LSD= Least significant difference. CV= coefficient of variantionV1= Itahari-4, V2= JRO-204, V3= NJ-7010 (Rani)

Intercrop Main Effect: The intercrop treatment showed strong and significant results in all analyses. In both 2022 and 2023, the jute and local mung bean system yielded the highest averages (20.19 t ha^{-1} and 21.07 t ha^{-1}, respectively), significantly exceeding sole-cropped jute (12.67 t ha⁻¹ and 13.55 t ha⁻¹). This trend changed in 2024, with the jute and Malepatan-1 cowpea intercrop yielding the most (37.30 t ha⁻¹), while sole jute had the least at 26.08 t ha⁻¹. The combined analysis affirmed the jute and Malepatan-1 cowpea system's superiority, yielding 25.95 t ha⁻¹, a 49% increase over sole-cropped jute (17.43 t ha⁻¹) (Table 5). Variety × Intercrop Interaction: Significant interactions across all years highlighted optimal variety-management pairings. The maximum stick yield throughout the study (40.00 t ha⁻¹) was attained by NJ-7010 (Rani) in the jute and Malepatan-1 cowpea system in 2024. This specific combination also achieved the highest yields for the interactions in 2022 (23.52 t ha⁻¹) and 2023 (24.40 t ha⁻¹), and generated the greatest mean (29.31 t ha⁻¹) in the combined analysis. In contrast, JRO-204 under sole cropping consistently yielded the lowest: 11.23 t ha⁻¹ (2022), 12.11 t ha⁻¹ (2023), 22.39 t ha⁻¹ (2024), and 15.34 t ha⁻¹ in the combined analysis (Table 5).

Effect on jute dry fiber yield

The analysis of dry fiber yield, the primary marketable product, showed consistent significant treatment effects across all environments. The main effects of variety, intercrop, and their interaction were significant in each individual year (2022, 2023, 2024) as well as in the combined analysis. Varietal Performance: In all analyses, distinct varietal differences emerged. NJ-7010 (Rani) led in fiber yields for 2022 (2.95 t ha⁻¹) and 2023 (3.34 t ha⁻¹), while JRO-204 consistently had the lowest yields (2.74 t ha⁻¹ and 3.15 t ha⁻¹). A notable change occurred in 2024, with Itahari-4 reaching the highest yield (4.24 t ha⁻¹) and NJ-7010 (Rani) recording the lowest (3.70 t ha⁻¹). This trend was also reflected in the combined analysis, where Itahari-4 had the highest yield (3.44 t ha⁻¹) and JRO-204 the lowest (3.20 t ha⁻¹) (Table 6).

Table 6. Effect of jute + legumes intercropping practices on jute dry fiber yield (t ha^{-1}) at JRP, Itahari

Treatments	2022				2023				2024				Combined			
	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean
Jute + Malepatan 1	2.7	3.72	3.81	3.41	3.38	4.17	4.23	3.93	4.4	4.21	4.46	4.36	3.49	4.03	4.17	3.9
Jute + Sarlai tane	2.67	2.26	2.63	2.52	3.35	2.68	3.04	3.02	4.74	3.86	3.76	4.12	3.59	2.93	3.14	3.22
Jute + Mung local	3.65	2.91	2.55	3.03	4	3.32	2.9	3.41	4.63	4.18	3.73	4.18	4.09	3.47	3.06	3.54
Jute + Mung Pratikshya	2.45	3.07	3.55	3.02	2.8	3.42	3.9	3.37	4.06	3.57	3.37	3.66	3.1	3.35	3.61	3.35
Jute Sole crop	2.53	1.73	2.23	2.16	2.88	2.18	2.65	2.57	3.36	2.8	3.2	3.12	2.92	2.24	2.69	2.62
Mean	2.8	2.74	2.95	2.83	3.28	3.15	3.34	3.26	4.24	3.72	3.7	3.89	3.44	3.2	3.33	3.33
F-Value (Variety)				**				*				*				*
LSD (0.05)				0.11				0.13				0.53				0.26
F-Value (Treatment)				**				**				*				*
LSD (0.05)				0.14				0.17				0.69				0.33
F-Value (Var x Trt)				**				**				*				*
LSD (0.05)				0.25				0.29				1.19				0.58
C.V (%)				5.3				5.3				18.4				9.67

*= Significant at P ≤ 0.05. **= P≤0.01. LSD= Least significant difference. CV= coefficient of variantionV1= Itahari-4, V2= JRO-204, V3= NJ-7010 (Rani).

Intercrop Main Effect: The intercrop treatment had a consistent positive impact on dry fiber yield. The jute and Malepatan-1 cowpea system consistently produced the highest mean yields across all years: 3.41 t ha⁻¹ (2022), 3.93 t ha⁻¹ (2023), and 4.36 t ha⁻¹ (2024). In the combined analysis, it yielded 3.90 t ha⁻¹. Sole-cropped jute, on the other hand, yielded the lowest averages: 2.16 t ha⁻¹, 2.56 t ha⁻¹, 3.12 t ha⁻¹, and 2.62 t ha⁻¹ for the respective years and combined data (Table 6). This translates to a 49% advantage in yield for the best intercrop system compared to sole cropping in the pooled analysis.

Variety × Intercrop Interaction: Significant interactions showcased optimal pairings. The highest dry fiber yield recorded in this study (4.46 t ha⁻¹) occurred for NJ-7010 (Rani) in the jute and Malepatan-1 cowpea system in 2024. This combination also produced the top yields for the interactions in 2022 (3.81 t ha⁻¹) and 2023 (4.23 t ha⁻¹), resulting in the highest mean (4.17 t ha⁻¹) in the combined analysis. In stark contrast, JRO-204 under sole cropping yielded the lowest: 1.73 t ha⁻¹ (2022), 2.18 t ha⁻¹ (2023), 2.80 t ha⁻¹ (2024), and 2.24 t ha⁻¹ in the combined analysis (Table 6).

Effect on jute dry stick yield

The dry stick yield, an important biomass byproduct, showed a clear pattern of treatment effects. The variety's main effect was not significant in 2022 and 2023, but the intercrop and the combination of variety and intercrop were significant in both years.

Table 7. Effect of jute + legumes intercropping practices on jute dry stick yield (t ha^{-1}) at JRP, Itahari

Treatments	2022				2023				2024				Combined			
	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean
Jute + Malepatan 1	6.17	6.71	6.86	6.58	6.58	6.99	7.27	6.94	8.63	8.81	14.46	10.63	7.13	7.50	9.53	8.05
Jute + Sarlai tane	5.97	5.34	5.88	5.73	6.38	5.75	6.29	6.14	14.42	9.84	9.59	11.29	8.92	6.98	7.25	7.72
Jute + Mung local	8.03	6.94	5.81	6.92	8.44	7.31	6.22	7.32	11.59	10.97	9.78	10.78	9.35	8.41	7.27	8.34
Jute + Mung Pratikshya	5.94	6.39	7.18	6.5	6.35	6.8	7.59	6.91	8.81	8.4	10.46	9.22	7.03	7.20	8.41	7.54
Jute Sole crop	4.6	4.05	3.66	4.1	5.01	4.46	4.07	4.51	8.31	7.94	8.31	8.19	5.97	5.48	5.35	5.60
Mean	6.14	5.89	5.88	5.97	6.55	6.26	6.29	6.37	10.35	9.19	10.52	10.02	7.68	7.11	7.56	7.45
F-Value (Variety)				ns				ns				ns				ns
LSD (0.05)				-				-				-				-
F-Value (Treatment)				**				**				ns				*
LSD (0.05)				0.68				0.69				-				0.81
F-Value (Var x Trt)				*				*	*			ns	*			ns
LSD (0.05)				1.18				1.21				-				
C.V (%)				11.9				11.3				18.0				15.70

*= Significant at P ≤ 0.05. **= P≤0.01. LSD= Least significant difference. CV= coefficient of variantionV1= Itahari-4, V2= JRO-204, V3= NJ-7010 (Rani)

In the combined analysis, only the intercrop main effect was significant, indicating a consistent effect over time. Intercrop Main Effect: The cropping system had a noticeable and consistent impact on dry stick production. In 2022 and 2023, the jute and local mung bean intercrop system produced the highest yields (6.92 t ha^{-1} and 7.32 t ha^{-1}, respectively), significantly outperforming sole-cropped jute, which yielded the lowest (4.10 t ha^{-1} and 4.51 t ha^{-1}). This was confirmed in the combined analysis where the jute and local mung bean system yielded 8.34 t ha^{-1}, a 49% increase over the yield from sole cropping (5.60 t ha^{-1}) (Table 7). Variety × Intercrop Interaction: The significant interactions from 2022 and 2023 highlighted high-performing combinations. The NJ-7010 (Rani) variety, when intercropped with Malepatan-1 cowpea, consistently showed the highest dry stick yields: 6.86 t ha^{-1} in 2022 and 7.27 t ha^{-1} in 2023. Conversely, the lowest yields for these years were recorded for the same NJ-7010 (Rani) variety under sole cropping: 3.66 t ha^{-1} (2022) and 4.07 t ha^{-1} (2023) (Table 7).

Intercrop yield equivalent to jute fiber

The legume yield from the intercrop was significantly influenced by treatment each year and in the combined analysis. As expected, sole-cropped jute produced no yield of legumes. The jute and Malepatan-1 cowpea intercrop system consistently delivered the highest yield of legumes across all environments, yielding 1.54 t ha^{-1} in 2022, 1.56 t ha^{-1} in 2023, and 1.40 t ha^{-1} in 2024. In the overall analysis, the jute and Malepatan-1 cowpea intercrop yielded the highest mean of 1.50 t ha^{-1} (Table 8). The jute and local mung bean intercrop yielded lower but still significant amounts of grain. The yield from the legume component adds direct value to the intercropping systems, enhancing total productivity and farm income.

Table 8: Intercrop yield (t ha^{-1}) equivalent jute fiber in jute + legumes intercropping practices at JRP, Itahari

Treatments	2022				2023				2024				Combined			
	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean
Jute + Malepatan 1	1.46	1.61	1.56	1.54	1.55	1.56	1.57	1.56	1.37	1.32	1.5	1.4	1.46	1.50	1.54	1.50
Jute + Sarlai tane	1.12	1.17	1.13	1.14	1.16	1.12	1.23	1.17	1.4	1.29	1.45	1.38	1.23	1.19	1.27	1.23
Jute + Mung local	0.62	0.58	0.64	0.61	0.59	0.59	0.64	0.61	0.56	0.58	0.57	0.57	0.59	0.58	0.62	0.60

Treatments	2022				2023				2024				Combined			
	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean
Jute + Mung Pratikshya	0.48	0.51	0.42	0.47	0.48	0.54	0.42	0.48	0.61	0.57	0.59	0.59	0.52	0.54	0.48	0.51
Jute Sole crop	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Mean	0.74	0.77	0.75	0.75	0.76	0.76	0.77	0.76	0.79	0.75	0.82	0.79	0.76	0.76	0.78	0.77
F-Value (Variety)				ns				ns				ns				ns
LSD (0.05)				-				-				-				-
F-Value (Treatment)				**				**				**				**
LSD (0.05)				0.07				0.05				0.12				0.12
F-Value (Var× Trt)				ns				ns				ns				ns
LSD (0.05)				-				-				-				-
C.V (%)				9.7				9.4				16.8				11.57

*= Significant at P ≤ 0.05. **= P≤0.01. LSD= Least significant difference. CV= coefficient of variantionV1= Itahari-4, V2= JRO-204, V3= NJ-7010 (Rani). Values in parenthesis represent the jute fiber equivalent yield; rate of produce - jute fiber (Rs. 95 kg^{-1}), green cowpea pod (Rs.100 kg^{-1}), mung (Rs. 100 kg^{-1})

Jute equivalent yield of both crop

The Jute Fiber Equivalent Yield (JFEY), which represents total system productivity in terms of the main cash crop, was significantly impacted by the treatments. Analysis of variance indicated that JFEY was influenced by variety, intercrop treatment, and their interaction in 2022 and 2023. In 2024 and the combined analysis, the interaction between variety and intercrop was not significant, but the main effects of both continued to be significant.

Table 9. Jute equivalent yield (t ha^{-1}) in jute + legumes intercropping practices at JRP, Itahari

Treatments	2022				2023				2024				Combined			
	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean
Jute + Malepatan 1	4.16	5.33	5.37	4.95	4.94	5.74	5.8	5.49	5.77	5.53	5.96	5.75	4.96	5.53	5.71	5.40
Jute + Sarlai tane	3.79	3.43	3.75	3.66	4.51	3.8	4.27	4.19	6.14	5.15	5.21	5.5	4.81	4.13	4.41	4.45
Jute + Mung local	4.27	3.49	3.18	3.65	4.59	3.92	3.53	4.01	5.19	4.75	4.3	4.75	4.68	4.05	3.67	4.14
Jute + Mung Pratikshya	2.93	3.58	3.97	3.49	3.28	3.96	4.32	3.85	4.67	4.14	3.96	4.26	3.63	3.89	4.08	3.87
Jute Sole crop	2.53	1.73	2.23	2.16	2.88	2.18	2.65	2.57	3.36	2.8	3.2	3.12	2.92	2.24	2.69	2.62
Mean	3.53	3.51	3.70	3.58	4.04	3.92	4.11	4.02	5.03	4.47	4.52	4.68	4.20	3.97	4.11	4.09
F-Value (Variety)				**				**				*				*
LSD (0.05)				0.13				0.15				0.54				0.27
F-Value (Treatment)				**				**				**				*
LSD (0.05)				0.16				0.2				0.7				0.35
F-Value (Var x Trt)				**				*				ns				ns
LSD (0.05)				0.28				0.35				-				-
C.V (%)				4.7				5.2				15.5				8.47

*= Significant at P ≤ 0.05. **= P≤0.01. LSD= Least significant difference. CV= coefficient of variantionV1= Itahari-4, V2= JRO-204, V3= NJ-7010 (Rani). Values in parenthesis represent the jute fiber equivalent yield; rate of produce - jute fiber (Rs. 95 kg^{-1}), green cowpea pod (Rs.100 kg^{-1}), mung (Rs. 100 kg^{-1})

Varietal Performance: Significant differences in performance were observed among varieties. NJ-7010 (Rani) provided the highest JFEY in 2022 (3.70 t ha^{-1}) and 2023 (4.11 t ha^{-1}), while JRO-204 yielded the least in those years (3.51 and 3.92 t ha^{-1} respectively). In 2024 and in the overall analysis, Itahari-4 achieved the highest JFEY (5.03 and 4.20 t ha^{-1}), with the lowest yields from JRO-204 (4.47 and 3.97 t ha^{-1}) (Table 9). Intercrop Main Effect: The cropping system consistently showed a positive impact on total productivity. The jute and Malepatan-1 cowpea intercrop yielded the greatest JFEY in all settings: 4.95 t ha^{-1} (2022), 5.49 t ha^{-1} (2023), and 5.75 t ha^{-1} (2024). In the combined analysis, it yielded 5.40 t ha^{-1}. In contrast, sole-cropped jute consistently produced the lowest JFEY: 2.16, 2.56, 3.12, and 2.67 t ha^{-1} for the respective years and for the combined data (Table 9). This shows a 102% improvement in productivity from the top intercrop system compared to sole cropping across the pooled analysis. Variety × Intercrop Interaction: In the notable years (2022 and 2023), the interactions specified optimal pairings. The combination of NJ-7010 (Rani) with the jute and Malepatan-1 cowpea intercrop yielded the highest JFEY (5.37 t ha^{-1} in 2022 and 5.79 t ha^{-1} in 2023). The lowest JFEY during these interactions was recorded for JRO-204 under sole cropping (1.73 t ha^{-1} in 2022) (Table 9).

Economic Analysis: Net Return

The net returns, as a measure of the economic feasibility of the systems, were significantly impacted by the various experimental factors. The analysis of variance showed that net returns were affected by variety, intercrop treatment, and their interaction in 2022, 2023, and the combined analysis. In 2024, only the main effects of variety and intercrop were significant, and the interaction was not significant. Varietal Performance: Differences in profitability among varieties were marked. NJ-7010 (Rani) generated the highest net returns in 2022 (Rs. 355,268 ha⁻¹), 2023 (Rs. 394,518 ha⁻¹), and in the overall analysis (Rs. 402,732 ha⁻¹), while JRO-204 saw the lowest returns during these years. In contrast, Itahari-4 proved to be the most profitable variety in 2024 (Rs. 481,455 ha⁻¹), while JRO-204 remained the least profitable (Table 10).

Table 10. Net return (NRs in 000 ha^{-1}) obtained from jute + legumes intercropping practices at JRP, Itahari

Treatments	2022				2023				2024				Combined			
	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean
Jute + Malepatan 1	402.17	514.38	517.93	478.16	476.75	552.8	558.52	529.36	555.33	532.39	573.28	553.67	478.08	533.19	549.91	520.39
Jute + Sarlai tane	365.33	331.88	362.04	353.08	433.92	366.46	411.63	404	590.39	495.28	501.78	529.15	463.21	397.87	425.15	428.74
Jute + Mung local	409.08	333.98	305.44	349.5	439	374.89	338.69	384.19	496.17	454.56	411.67	454.13	448.08	387.81	351.93	395.94
Jute + Mung Pratikshya	280.42	342.49	378.76	333.89	313.67	379.08	412.01	368.25	446.61	396.17	378.83	407.2	346.9	372.58	389.87	369.78
Jute Sole crop	240.03	163.88	212.17	205.36	273.28	206.63	251.75	243.89	318.78	266	304	296.26	277.36	212.17	255.97	248.5
Mean	339.41	337.32	355.27	344	387.32	375.97	394.52	385.94	481.46	428.88	433.91	448.08	402.73	380.72	394.57	392.67
F-Value (Variety)				*				*				*				*
LSD (0.05)				12.14				14.92				51.67				26.24
F-Value (Treatment)				**				**				**				**
LSD (0.05)				15.67				19.26				66.71				33.88
F-Value (Var × Trt)				**				**				ns				*
LSD (0.05)				27.14				33.36				-				45.15
C.V (%)				4.7				5.2				15.4				8.43

*= Significant at P ≤ 0.05. **= P≤0.01. LSD= Least significant difference. CV= coefficient of variantionV1= Itahari-4, V2= JRO-204, V3= NJ-7010 (Rani). Values in parenthesis represent the jute fiber equivalent yield; rate of produce - jute fiber (Rs. 95 kg^{-1}), green cowpea pod (Rs.100 kg^{-1}), mung (Rs. 100 kg^{-1})

Intercrop Main Effect: The cropping system had a decisive and consistent effect on profitability. The jute and Malepatan-1 cowpea intercrop yielded the highest net returns in all environments: Rs. 478,161 ha⁻¹ (2022), Rs. 529,356 ha⁻¹ (2023), and Rs. 553,667 ha⁻¹ (2024). In the combined analysis, this system produced a mean net return of Rs. 520,391 ha⁻¹. Sole-cropped jute consistently resulted in the lowest net returns across all assessments, averaging Rs. 248,500 ha⁻¹ in the combined analysis (Table 10). This translates into a 109% rise in net returns for the best intercrop system compared to sole cropping. Variety × Intercrop Interaction: In the significant analyses (2022, 2023, combined), the interaction identified the most economically advantageous combinations. The pairing of NJ-7010 (Rani) with the jute and Malepatan-1 cowpea intercrop was consistently the most lucrative, yielding the highest returns of Rs. 517,933 ha⁻¹ (2022), Rs. 558,517 ha⁻¹ (2023), and Rs. 549,913 ha⁻¹ in the combined analysis. On the contrary, JRO-204 under sole cropping consistently resulted in the lowest net returns for these significant interactions (Rs. 163,880 ha⁻¹ in 2022, Rs. 206,630 ha⁻¹ in 2023, and Rs. 212,720 ha⁻¹ in the combined analysis) (Table 10).

DISCUSSION

This three-year experiment highlights that intercropping tossa jute with short-duration legumes like cowpea and mung bean significantly boosts jute growth, biomass, fiber yield, and net returns compared to growing jute by itself. Throughout the years, the effects of intercrop treatments and the variety × intercrop interactions proved to be more impactful than the variety alone, emphasizing that the choice of intercrop (cowpea or mung bean) is crucial for system performance. This finding is in line with broader research showing that legume-based intercropping typically enhances overall productivity and profitability over monoculture by improving resource utilization and providing an additional product stream, as noted by Shanker and Majumdar (2013).

Basal diameter, which is a key factor for structural strength and potential fiber yield, showed significant growth under intercropping, especially in the jute and Malepatan-1 cowpea system, which repeatedly produced larger stem diameters across the seasons (Table 2). This increase in stem girth likely indicates better nutrient availability, particularly nitrogen from the legume through biological fixation, along with improved soil moisture retention and other structural advantages typical of diverse systems (Maitra et al 2021). Similar enhancements in jute stem structure due to legume association have been noted by Prasad et al (2019), reinforcing the role of below-ground interactions in improving crop performance in rainfed agricultural settings. Intercropping also significantly improved overall biomass and economic yield components. Key metrics like green plant yield, green fiber yield, and stick yield all saw considerable increases under intercropping, particularly with the jute and Malepatan-1 cowpea system excelling in most years (Tables 3, 4, 5). In the combined analysis, green plant yield grew from 37.7 t ha^{-1} with sole cropping to 58.8 t ha^{-1} with jute and cowpea, marking a 56% increase in total biomass production. Similarly, green fiber yield jumped by 48% under the same system (Table 4). This significant biomass edge likely stems from enhanced nitrogen availability due to legume fixation, minimized weed competition, and more effective use of space and light resources—factors well-documented in multifunctional cropping systems (Stomph et al 2020).

The strong positive relationship between fiber yield and intercropping (an increase of 30–45% compared to sole cropping depending on the year) suggests that the complementary growth habits of jute and cowpea were particularly advantageous. The Malepatan-1 cowpea variety's slower initial growth and broader leaves likely helped conserve soil moisture and suppress weeds, reducing competition during jute's critical early growth phase. This aligns with findings by Ghorai et al (2016), who highlighted how decreased weed pressure early on can significantly enhance fiber development and final yield in jute systems. Dry fiber yield, the main marketable product, followed a similar pattern, with top yields consistently seen in the jute and Malepatan-1 cowpea system across all years and in the combined analysis (3.90 t ha^{-1}) (Table 6). This represented a 49% increase over sole cropping (2.62 t ha^{-1}). The substantial rise in fiber output reinforces the benefits of complementary resource utilization and the positive associative effects like in-situ nitrogen transfer and enhanced soil health that legumes bring to jute-based cropping systems (Hossain et al 2025). The reliability of these benefits over multiple seasons emphasizes the role of cowpea intercropping as a resilient approach to boost productivity and financial stability in rainfed jute farming.

The yield from the legume intercrop further added to overall system productivity. Cowpea (Malepatan-1) contributed the highest extra output, delivering between 1.40 and 1.56 t ha^{-1} of grain across the seasons (Table 8). When evaluated as Jute Fiber Equivalent Yield (JFEY), integrating the value of both crops, the jute plus cowpea (Malepatan-1) system reached a mean of 5.40 t ha^{-1} in the combined analysis (Table 9), more than double the productivity of sole jute (2.67 t ha^{-1}). This highlights a significant land-equivalent advantage, affirming that intercropping better captures and converts available resources. These findings are consistent with previous studies indicating enhanced Land Equivalent Ratios (LER) and overall system productivity in legume-jute combinations (Chakraborty et al 2021). The economic viability of the systems mirrored these trends, reflecting both improved jute performance and the added value from intercropping. In the combined analysis, the jute and cowpea (Malepatan-1) system yielded the highest net returns of Rs. 520,391 ha^{-1} (Table 10), representing a 109% increase over sole cropping (Rs. 248,500 ha^{-1}). This financial advantage is particularly significant in light of rising input and labor costs, showing intercropping as a profitable and risk-resistant strategy for smallholder farmers (Khakbazan et al 2025). The improved returns arise from effectively utilizing previously untapped ecological niches like space light, and soil nutrients derived from the combination of crops, a benefit lost in monoculture systems (Legba et al 2025).

CONCLUSION

This study demonstrates over three years that intercropping jute with short-duration legumes, particularly cowpea (Malepatan-1), greatly boosts biological productivity, fiber yield, and the economic viability of jute farming systems in Nepal. While varietal differences among Itahari-4, JRO-204, and NJ-7010 were generally non-significant for most growth and yield traits, the impact of intercrop species and their interactions with jute varieties was firmly significant across the board. Cowpea (Malepatan-1) emerged as the most compatible and productive intercrop, yielding the highest green biomass, green fiber, dry fiber, and dry stick figures, along with a superior intercrop fiber-equivalent yield. The noticeable rise in Jute Fiber Equivalent Yield (JFEY) and net returns more than double compared to sole jute highlights the strong economic benefits of legume-based intercropping. Mung bean (Local) also contributed positively, especially regarding plant height, basal diameter, and stick yield.

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AUTHORS' CONTRIBUTION

SR Tripathi: Conceptualized and designed the experiments, conducted the research, analyzed and interpreted the data and drafted the manuscript

S Karki and TR Rijal: Contributed to conducted the research, data analysis and drafting manuscript.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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