



## Intercropping rice (*Oryza sativa*) with jute (*Corchorus capsularis*) and its impact on total productivity and profitability under rainfed lowland ecology

A. GHOSH

Central Rice Research Institute, Cuttack, Orissa 753 006

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### ABSTRACT

A field study was conducted to work out the advantages of growing rice (*Oryza sativa* L.) and jute (*Corchorus capsularis* L.) at different intercrop configurations under rainfed lowland situation during wet season in 2007 and 2008 at Cuttack. Three different intercropped stands, viz., one row of jute alternated with one (1:1), two (2:1) and four (4:1) rows of rice were compared with their respective pure stands under three levels of nitrogen, [0, 40 and recommended (for rice) N of 60 kg/ha]. Results showed comparable grain yield of rice under sole (3.80 and 3.30 t/ha in 2007 and 2008) and 4:1 intercropped stand (3.56 and 3.12 t/ha in 2007 and 2008), which were significantly higher than the other intercropped stands. Fibre yield at pure stands (2.54 and 2.15 t/ha in 2007 and 2008) was significantly higher than those at intercropped stands; while among intercropped stands, it was significantly higher (1.40 and 1.26 t/ha) at 1: 1 stand ratio. Studies on N management determined an optimum dose of 60 kg N/ha ensuring higher yield and N uptake in jute, which was however comparable with 40 kg N/ha in rice. Besides pure stands, N uptake at intercrop stands was higher at 4:1 and 1:1 stands in rice and jute respectively. Advantages of their intercropping as adjudged with land equivalent ratio and area time equivalent ratio were greater in 4:1 stands, deriving higher system productivity (5.22 and 4.55 t/ha), net return (₹13,164 and 13,729) and B:C ratio (1.68 and 1.72) and also higher system uptake of N (74.3 and 78.5 kg N/ha). Therefore, the study could suggest intercropping rice with jute at 4:1 stand ratio treated with 40 kg N/ha for enhancing total productivity and profitability of the rainfed lowland rice production system.

**Key words :** Intercropping system, Jute, N management, Rainfed lowland, Rice

Traditionally, mono-crop culture with rainy season (*kharif*) rice prevailed in rainfed lowlands during wet season is not well remunerative. Possibilities are there to enhance its productivity per unit area and time too, which could turn lowland rice farming into a profitable enterprise (Maclean *et al.*, 2002). To improve the productivity scenario as well as to ascertain appropriate risk management of this ecology needs crop diversification to be ventured exploring several other ecology based crops under this situation.

Jute is found to thrive well under waterlogged situation, jute-rice cropping system becomes predominant, particularly under water logged low lying areas in eastern India (Singh and Ghosh, 1999). Lots of studies have been conducted reporting rice cultivation in sequence with jute. However, reports are still meagre suggesting rice and jute cultivation concurrently at the same piece of land with a definite mixed stand ratio (Ghosh *et al.*, 2002). Therefore, it is imperative to study on rice with jute intercrop system

ascertaining supplementary yield advantages of the system in totality. Additionally, in view of *in situ* green manuring by virtue of jute leaf fall, appropriate N dose needs to be determined for optimum productivity, also. The present field study was carried out identifying a compatible stand ratio of rice and jute intercropping systems along with optimum N requirement.

### MATERIALS AND METHODS

A field experiment was carried out at the Research Farm of Central Rice Research Institute, Cuttack during wet season in 2007 and 2008. The study was conducted under typical rainfed shallow lowland situation, where water depth usually varies from 0 to 30 cm throughout the growing season. The experimental site was located at a geographic position of 20° 30' North and 86° 0' East, and at an altitude of 22 m above mean sea level. The soil was *aeric, heplaquept* analyzing 0.83% organic C, 0.09% total Kjeldahl N, 12 mg/ kg soil available phosphorus, 65 mg/ kg soil available potash and pH of 6.8.

Long duration rice 'Gayatri' was intercropped with jute,

'Sonali' (JRC 321) at end of May using recommended seed rate of 80 kg/ha (rice) and 7.5 kg/ha (jute). Rice was dibble-sown at 15 cm plant spacing within 20 cm row interval; while jute was dibble-sown in-between rice lines at spacing of 7 cm (plant) x 20 cm (row). Crops grown in a replacement series intercropping system constituted three different intercropped stands, viz., one row of jute alternated with one (1:1), two (2:1) and four (4:1) rows of rice respectively, which were compared with their respective pure stands under three levels of nitrogen, no N, 40 kg N/ha and 60 kg N/ha. P and K were applied at uniform dose, 17.48 and 33.33 kg/ha respectively. All the fertilizers were applied during sowing in both types of crop stands. No separate fertilizer schedule or amount was applied in jute in isolation. The experiment was laid out in a split-plot design, randomly distributing level of N in main plot and stand ratio in sub pot of 20 m<sup>2</sup> net plot size with 4 replicates. Jute was harvested at end of August; while rice was harvested at end of November. Plant height and girth of jute was measured taking mean of top, middle and bottom portion of ten plants. Intercropping indices, viz., Aggerissivity, land equivalent ratio (LER), mometary advantage, relative crowding coefficient, relative value total and area time equivalent ratio (ATER) determined the relative advantages of this system, and net return and benefit - cost ratio estimated the magnitude of profitability of this intercropping system, were work out following standard procedure.

## RESULTS AND DISCUSSION

### Rainfall pattern and initial crop stand

Germination and emergence of both the crops were satisfactory following pre-monsoon shower (99 and 72 mm in 2007 and 2008) ensuring better initial stand in both the years. Total rainfall received during the growing seasons was normal (1780 and 1551 mm, respectively); however, its distribution pattern was erratic across the cropping season (May-November) in both the years. Maximum rain (89 and 94% in 2007 and 2008) occurred during June to Sep-

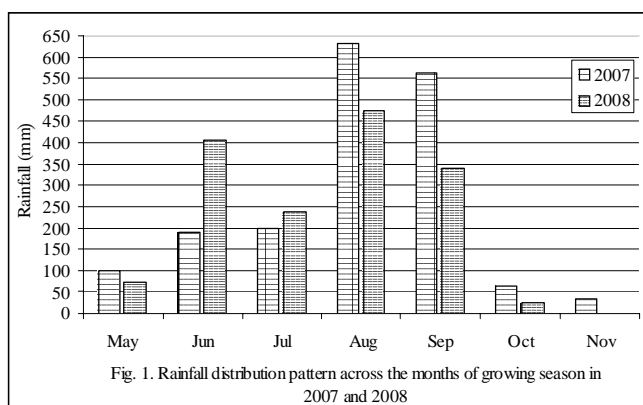


Fig. 1. Rainfall distribution pattern across the months of growing season in 2007 and 2008

tember (Fig.1). June' 07 and July' 08 received the lowest amount, only 12 -15% of the total seasonal rainfall. Of which, less than 20-25% was received during mid June' 07 and mid July' 08 that resulted in prolonged drought witnessing *gajja marudi* (dieing young and germinated seedlings) of both the crops pronouncing more damage in jute than in rice stands.

Since last week of June, water started accumulating in the field and slowly increased in depth fluctuating mostly within 15-30 cm throughout the growing period in both the years. While, initial crop growth got momentum with adequate water availability encouraging elongation in plant height (faster in jute than rice). Thus, complete crop submergence never happened in any stage, water level remained much below the tip of the jute plant, instead and did not affect the usual growth of jute and fibre yield subsequently.

Heavy rain during 3<sup>rd</sup> week of September (>55% of the total monthly rainfall) in 1<sup>st</sup> year and 1<sup>st</sup> week of October (>70% of the total monthly rainfall) in 2<sup>nd</sup> year caused unusual water logging up to 40 cm in the field. This situation did not affect much to jute stand as it was harvested by that time; while it affected panicle initiation in rice suppressing grain yield as compared with that in 1<sup>st</sup> year.

### Growth and yield of jute and N use efficiency

The species of jute (*Capsularis*), considered for the study under this experiment, was developed keeping in view of its adaptability under rainfed shallow lowland condition (0-30 cm water depth). In this present study, the maximum water depth prevailed across the growth stages of jute was 30 cm, remained for a period of 15 days during 4 week of July to first week of August coinciding with its later vegetative stage. Thus, growth and fibre yield were no way affected with water accumulation.

Across the years, significant differences in plant population were noticed on account of different stand ratios (Table 1). In 2007, crop growth and vigour was comparatively better than 2008, which was attributed to the higher amount of rainfall with better distribution across the season. Plant population declined in intercropped stands as compared with that in pure stand pronouncing the highest population at 1:1 intercrop stand. These differential plant populations were ascribed with proportionate lines of seeding jute within usual rice stands. On the other hand, N levels caused no significant differences in plant population.

In both the years, plant height at pure stand was significantly higher than that at all intercrop stands. Narrow row spacing (<33%) for jute in intercrop stands aggravated the competition for temporal and spatial resources, particularly at primary stage that restricted its initial growth sup-

pressing plant elongation. Plant height showed a different trend within the intercrop stands across the year also. In 2007, variation in stand arrangement did not impact plant resulting comparable height in all three stands; while in 2008, plant height in 4:1 stand was significantly higher than other two stands, which were however at par. Furthermore, it is to be mentioned that row/plant spacing in jute under all intercrop stands remained alike, *i.e.* 20/7cm. It implied its identical growth and development in all intercrop condition creating no additional vigour in 1:1 stand that could induce extra elongation. Plant girth remained unaffected despite variation in their stand ratios compared with the pure stand; while it increased with higher N dose.

Variable stand ratios under intercrop situation affected biomass and fibre yield significantly. Pure jute stand pro-

duced consistently higher biomass and fibre yield over the years; while they declined significantly with decreasing plant population under different intercrop stands. Jute stands at 1:1 ratio out-yielded other stands significantly producing more biomass and fibre, closely followed by 2:1 ratio. This was attributed to respective plant population under different intercrop stands accounting for higher density under 1:1 compared with other stand ratios (Ghosh *et al.*, 2001); while the lowest biomass and fibre yield was at 4:1 stand ratio. Over the years, biomass and fibre yield was higher in 2007 on account of better rainfall and its distribution pattern.

Variable N management significantly affected growth and yield of jute, except plant population that remained unaffected at all stands. Higher N dose of 60 kg /ha pro-

**Table 1.** Growth, yield and N uptake of jute under pure and intercrop stands in rainfed lowland situation

	Plant population (lakhs/ha)		Plant height (cm)		Plant girth (cm)		Fresh biomass yield (t/ha)		N use efficiency (kg fibre/kg N applied)		N uptake (kg/ha)	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
<i>Intercropping systems</i>												
Pure crop	2.64	2.32	239	231	4.25	4.05	35.5	32.20	52.8	43.4	50.2	42.8
Rice + jute (4:1)	0.58	0.44	211	209	4.16	3.96	14.5	13.25	16.5	12.8	20.5	17.2
Rice + jute (2:1)	0.80	0.66	188	186	4.20	4.00	17.0	15.00	19.7	14.7	24.4	21.2
Rice + jute (1:1)	1.30	1.14	185	171	4.15	4.00	20.0	18.50	20.0	15.7	28.2	25.0
SEm+	0.07	0.06	9.64	7.14	0.038	0.035	0.74	0.55	1.68	1.98	0.93	0.78
CD (P=0.05)	0.20	0.18	27	20	NS	NS	2.0	1.50	5.12	6.05	2.6	2.2
<i>N-levels (kg/ha)</i>												
0	2.45	2.20	177	165	3.68	3.30	2.32	2.60	--	--	14.5	16.0
40	2.50	2.30	217	200	3.93	3.50	6.64	5.68	25.8	20.1	38.4	37.7
60	2.60	2.45	236	226	4.12	3.81	9.64	7.72	28.7	23.2	55.8	51.5
SEm+	0.028	0.02	10.4	8.6	0.07	0.05	0.92	0.83	0.60	0.68	0.71	0.64
CD (P=0.05)	NS	NS	28	23	0.20	0.14	2.50	2.25	2.00	2.15	2.0	1.8

**Table 2.** Growth, yield and N uptake of rice in pure and intercrop stands under rainfed lowland situation

Treatment	Plant height (cm)		Panicles (m <sup>2</sup> )		Grains/panicle		1,000 grain weight (g)		Biological yield (t/ha)		N use efficiency (kg grain/kg N applied)		N uptake (kg/ha)	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
<i>Intercropping systems</i>														
Pure crop	124	121	275	260	180	176	25.4	25.2	9.30	8.50	74.8	68.9	62.2	60.5
Rice + jute(4:1)	122	119	270	258	176	174	25.0	25.2	7.96	7.32	72.5	66.1	58.0	57.1
Rice + jute(2:1)	115	113	262	248	177	175	24.7	24.8	6.58	6.00	56.1	37.8	48.1	51.6
Rice + jute(1:1)	110	100	255	245	174	173	24.5	25.0	5.09	4.35	41.0	32.0	38.1	33.9
SEm+	1.11	0.74	1.78	1.43	1.85	1.62	0.80	0.68	0.48	0.43	0.65	0.80	1.67	1.55
CD (P=0.05)	3	2	5	4	5	NS	NS	NS	1.35	1.20	2.00	2.50	4.5	4.2
<i>N-levels (kg/ha)</i>														
0	118	114	233	227	172	170	24.5	24.0	3.78	3.97	--	--	20.2	16.3
40	124	120	255	248	175	173	25.7	25.2	9.06	8.88	70.5	66.8	64.8	61.2
60	130	125	260	255	178	175	26.4	26.0	9.35	9.26	51.7	45.6	65.8	62.4
SEm+	1.15	0.77	2.22	1.85	1.88	1.80	0.95	0.87	0.51	0.48	1.70	2.10	1.55	1.41
CD (P=0.05)	3	2	6	5	NS	NS	NS	NS	1.42	1.35	5.25	6.50	4.2	3.8

moted growth and development of all yield parameters resulting significantly higher biomass and fibre yield. The gradual enhancement in fibre yield with increasing N doses corroborated with the previous observations reporting appropriate N requirement for optimal fibre yield (Saha *et al.*, 2000). Interaction of stand ratios with N management showed significant variation in fibre yield, pronounced more in 2007 (Table 4). In both the years, stands treated with 60 kg N/ha produced significantly higher fibre yield. Besides pure stand, N uptake was higher in 1:1 stands that significantly declined with decreasing population. N use efficiency was derived higher in pure jute stand accounting for 52.8 and 43.4 kg fibre/kg N applied during 2007 and 2008; while applying 60 kg N /ha showed higher N use efficiency, 28.7 and 23.2 kg fibre/ kg N applied.

#### Growth and yield of rice and N-use efficiency

In 2007, crop growth and vigour was better than that in 2008, which was attributed to better rainfall and its distribution pattern. In both the years, plant height in pure rice stand was comparable with that in 4:1 stand, which was significantly longer than other stands (Table 2). This growth suppression in 1:1 and 2:1 stands was due to the shading effects of intercropped jute stands that inhibited the initial growth and development of rice therein. Significant difference in plant height was also attributed to different N management accounting for maximum plant height with N<sub>60</sub> followed by N<sub>40</sub>. Panicle numbers were recorded comparable in crops at pure as well as at 4:1 intercrop stands; while it declined in other stands. Development of grain in panicle was inconsistent across the year accounting for significant difference between pure and 1:1 stand

**Table 3.** Productivity, N uptake and economics of production of sole rice and jute and their intercropped stands under different N-levels

Treatment	Rice grain yield (t/ha)		Pooled grain yield (t/ha)	Fibre yield of jute (t/ha)		Pooled fibre yield (t/ha)	System uptake of N (kg/ha)		System productivity (t/ha)* in terms of rice grain equivalent		Net return (× 10 <sup>3</sup> ₹/ha)	
	2007	2008		2007	2008		2007	2008	2007	2008	2007	2008
<i>Intercropping systems</i>												
Sole crop	3.80	3.30	3.45	2.54	2.15	2.25	50.2/62.2 <sup>#</sup>	42.8/60.5 <sup>#</sup>	3.80/4.10 <sup>#</sup>	3.30/3.04 <sup>#</sup>	5.56/4.40 <sup>#</sup>	6.58/1.68 <sup>#</sup>
Rice + Jute (4:1)	3.56	3.12	3.25	1.03	0.92	0.90	78.5	74.3	5.22	4.55	13.16	13.73
Rice + Jute (2:1)	2.95	2.82	2.75	1.22	1.00	1.05	72.5	72.8	4.92	4.24	12.02	13.10
Rice + Jute (1:1)	2.34	1.85	2.00	1.40	1.26	1.25	66.3	58.9	4.60	3.63	10.52	9.04
SEm+	0.09	0.08	0.08	0.057	0.061	0.058	0.78	0.70	0.37	0.33	0.37	0.34
CD (P=0.05)	0.30	0.26	0.22	0.15	0.16	0.16	2.40	2.2	1.10	1.00	1.10	1.03
<i>N-levels (kg/ha)</i>												
0	1.28	0.97	1.10	0.63	0.60	0.56	34.7	32.2	2.30	1.82	-4.41	-4.99
40	4.10	3.64	3.75	1.66	1.40	1.45	103.2	98.6	6.78	5.62	13.37	13.32
60	4.17	3.70	3.80	2.41	1.99	2.00	121.6	113.9	8.06	6.52	18.30	18.03
SEm+	0.03	0.03	0.03	0.18	0.17	0.17	1.7	1.8	0.07	0.05	0.68	0.62
CD (P=0.05)	0.10	0.09	0.08	0.50	0.45	0.48	5.5	6.0	0.20	0.16	0.20	0.19

# - jute/ rice, Price of rice and jute in 2007- ₹6,200.00/t and ₹10,000/t, Price of rice and jute in 2008-₹7,450/t and ₹10,550/t

**Table 4.** Interaction effects of different cropping systems and N levels on fibre yield (t/ha) of jute and grain yield of rice during 2007 and 2008

N-level (kg/ha)	2007						2008					
	0		40		60		0		40		60	
	Jute	Rice	Jute	Rice	Jute	Rice	Jute	Rice	Jute	Rice	Jute	Rice
Pure crop	0.80	1.47	3.03	4.95	3.79	4.98	0.75	1.09	2.78	4.37	2.92	4.44
Rice + jute (4:1)	0.46	1.35	1.00	4.71	1.63	4.89	0.47	1.00	0.86	4.15	1.43	4.21
Rice + jute (2:1)	0.55	1.20	1.25	3.80	1.86	3.80	0.48	0.97	0.89	3.73	1.63	3.76
Rice + jute (1:1)	0.71	1.10	1.38	2.95	2.11	2.97	0.70	0.82	1.10	2.32	1.98	2.41
	<i>Jute</i>		<i>Rice</i>		<i>Jute</i>		<i>Jute</i>		<i>Rice</i>			
	SEm+	CD	SEm+	CD	SEm+	CD	SEm+	CD	SEm+	CD	SEm+	CD
		(P=0.05)		(P=0.05)				(P=0.05)		(P=0.05)		
Between stands	0.06	0.17	0.12	0.35	0.07	0.18	0.11	0.30				
Between N levels	0.21	0.58	0.07	0.20	0.23	0.60	0.06	0.16				

**Table 5.** Effect of intercropping system and nitrogen levels on 'competition functions' of rice and jute intercropping system during 2007 and 2008

Treatment	Aggressivity		Relative Crowding Coefficient		Area Time Equivalent Ratio		Relative Value Total		Land Equivalent Ratio		Monetary Advantage ( $\times 10^3$ ₹/ha)	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
$N_0$												
Rice + jute (4:1)	1.72	1.98	24.6	18.0	1.20	1.23	1.11	1.18	1.50	1.55	6.56	9.91
Rice + jute (2:1)	0.90	0.59	19.7	14.38	1.16	1.21	1.15	1.26	1.51	1.53	6.01	5.14
Rice + jute (1:1)	0.30	0.37	13.40	12.5	1.09	1.12	2.09	2.31	1.44	1.48	5.24	4.43
$N_{40}$												
Rice + jute (4:1)	0.45	0.54	9.61	8.49	1.12	1.10	1.08	1.07	1.28	1.26	11.73	9.83
Rice + jute (2:1)	0.30	0.30	2.31	2.74	0.97	1.01	1.14	1.10	1.18	1.17	6.86	5.99
Rice + jute (1:1)	0.27	0.27	1.23	0.73	0.82	0.73	2.20	1.67	1.06	0.92	2.28	3.00
$N_{60}$												
Rice + jute (4:1)	0.91	0.70	40.72	17.75	1.20	1.19	0.99	1.07	1.41	1.44	17.12	15.29
Rice + jute (2:1)	0.15	0.44	3.07	23.76	1.01	1.12	1.18	1.15	1.25	1.41	9.91	13.83
Rice + jute (1:1)	0.07	0.28	1.85	2.51	0.87	0.88	1.85	1.89	1.16	1.22	5.99	6.55

in 2007. In contrast, variability in stands did not affect grain filling showing comparable weight of 1000 grain across different intercrop stands. Similar observations were also noticed on N management.

Grain yield and biological yield were consistently higher over the years in its pure stand, which was comparable with that in 4:1 stand ratio. Crops in 2007 gave more grain yield than that in 2008 attributed to the relatively well distributed higher rainfall (Ghosh 2000a). Grain yield under 2:1 and 1:1 stand ratios declined proportionately due to reduction in panicle numbers. Although tillering was encouraged as usual in crops under 2:1 and 1:1 stands on account of wider space following the harvest of jute, it could barely compensated for considerable difference in panicle numbers compared with pure or 4:1 stands per unit area basis (Ghosh 2000b). In both the years, grain yield as well as biological yield accountable for  $N_{40}$  was comparable with that in  $N_{60}$ . This was attributed to the supplementary N availability from jute leaves and residues. Interaction between stands and N management derived comparable grain yields at pure and 4:1 stand ratios with  $N_{60}$  and  $N_{40}$  respectively in both the years; however significantly higher than other stands (Table 4).

N uptake in both the years was significantly higher in pure stands; however, comparable with that in 4:1 stands; while N uptake in crops treated with  $N_{40}$  was comparable with  $N_{60}$  (Ghosh, 2008). N use efficiency was derived higher in pure rice stand accounting for 74.8 and 68.9 kg grain/kg N applied, closely followed by mixed stand of 4:1 ratio during 2007 and 2008; while applying 40 kg N/ha showed higher N use efficiency, 70.5 and 66.8 kg grain/kg N applied.

#### Competition functions and production economics

Advantages of jute and rice intercropping system was adjudged deriving different 'Competition Functions' across the year (Table 5). Positive value of 'Aggressivity' at all stand ratios and at all levels of N application established the dominance of the main crop, i.e., rice in the system. However, other functions, viz., 'Relative Crowding Coefficient', 'Area Time Equivalent Ratio', 'Relative Value Total', 'Land Equivalent Ratio' and 'Monetary Advantage' revealed benefits of the system. All these 'Competition Functions' showed higher benefit in 4:1 stand ratio followed by 2:1 ratio that went on increasing with increase in the level of N application. In addition, higher rice equivalent grain yield, net return as well as benefit-cost ratio were also in conformity with above information (Table 3). That also revealed higher profitability of 4:1 stand system as adjudged with net return, which was estimated some 30-50% and 65-75% more than that of pure stand of jute and rice respectively across the year.

Therefore, the consecutive two years field study suggest growing one row of jute alternated with 4 rows of rice for optimizing total system productivity. The study could also advocate curtailing 1/3rd of recommended N dose in rice while intercropping with jute without any compromise with yield decline.

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