



Fodder cum grain dual harvests from rice (*Oryza sativa*) for enhanced productivity in Andaman's

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ABSTRACT

An experiment was conducted during *kharif* 2016–17 to assess the impact of fodder harvest on grain production and system productivity of long duration photosensitive rice C-14-8. For this, five fodder harvest treatments, FHTs {no fodder harvest (FH) control, FH at 30, 45, 60 and 75 days after transplanting (DAT) of rice} were evaluated in Randomised Complete Block Design with four replications. The results revealed that 75 DAT FHT has produced significantly higher dry fodder and crude protein yields (6.30 and 0.538 t/ha), whereas 30 and 45 DAT FHTs has higher grain yields. However, the system productivity measured as rice equivalent yield and net income indicated that FH at 75 DAT was promising (4.23 t/ha and ₹ 19088/ha). Lodging in grain alone producing crop (95%) was reduced to 24% by taking FH at 75 DAT. Thus, the study establishes fodder cum grain production system of rice as a potential solution to augment fodder shortages while enhancing the grain production from ratoon owing to reduced lodging.

Key words: C-14-8, Fodder, Lodging, Productivity, Rice, Rice equivalent yield

Rice (*Oryza sativa* L.) is the sole staple crop cultivated in Andaman and Nicobar Islands whose production (12 593 tonnes; DES 2016-17) was far behind the demand (60000 t). In two rice cultivated districts (South Andaman and North & Middle Andaman), high rainfall (249 and 305 cm; 2000-2017 mean) received over prolonged periods (114.8 and 109.2 days; 2008-2017 mean) deter use of high yielding short/medium duration varieties/hybrids as timely fertilizer and pesticide application was either not possible due to continuous rains or even if possible, their efficiency was dismally reduced due to runoff losses. Further, the harvest and threshing operations can't be taken up in rainy months. Hence, long duration varieties are preferred. A tall (>200 cm), long duration (~ 200 days) and photosensitive *japonica* rice variety C-14-8 was introduced by Japanese into these Islands during 1940s got popular with farmers. This variety occupying about 70% of rice area (Subramani *et al.* 2014) has stable yields (>2 t/ha) under no and minimal inputs application and matures during rain free period (end of December/early January) irrespective of planting time, has a major drawback of severe lodging menace. Lodged

rice owing to impaired translocation of water and nutrients, decreased interception of light, microclimatic changes and deterioration of the photosynthetic activity yields poorly (Kono 1995). To tide over the lodging problem, farmers harvest the above ground biomass once after transplanting and use the same as livestock feed. Rice crop regrowth after fodder harvest producing shorter plants with strong tillers was found less prone to lodging and have better grain yields. Thus this dual harvest became a way of long duration rice crop production cum intensification practice in the Islands. In this context, a field study was made to standardise fodder harvest schedule so as produce higher fodder yields while minimizing the lodging problems in grain crop and thus to enhance grain, system productivity and economics over grain producing crop alone.

MATERIALS AND METHODS

Field study was carried out during two *kharif* (July - January) 2016–17 at Bloomsdale Research Farm of ICAR-Central Island Agricultural Research Institute (CIARI), Port Blair, Andaman & Nicobar Islands situated at 11° 38' 06" N latitude and 92° 39' 15" E longitude at an altitude of 14 m amsl. Each year a new field site was used for the study. Experimental clay loam soil with 6.3 pH was medium for organic carbon (0.61%; both years), available nitrogen (251 and 256 kg/ha), phosphorous (10.6 and 10.9 kg/ha) and low for available potassium (127 and 123 kg/ha) at the start of experiment in July 2016 and July 2017.

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Treatments: For standardization of fodder harvest (FH) schedules in rice, the study was initiated during 2016 with 3 fodder harvest treatments (FHTs), i.e. FH at 30 and 45 days after transplanting (DAT) along with no FH control in randomized block design (RBD) with seven replications. Two additional FHTs, i.e. at 60 and 75 DAT were also evaluated in micro plots (12 m² plots) with 4 replications. As the micro plot treatments performance was more promising to normal plot FHTs (30 & 45 DAT), these were included as the treatments in 2017 study and thus 5 FHTs, i.e. FH at 30, 45, 60 and 75 DAT along with no FH control were tested in RBD with four replications.

Field and crop management: Field was prepared by puddling thrice with power tiller followed by manual levelling and field lay out. Thirty-day old C-14-8 rice seedlings were transplanted at 20 cm × 15 cm spacing using 2 seedlings/hill on 5th and 3rd August 2016 and 2017. Rice crop received 100-26.4-36 kg/ha nitrogen (N) - phosphorus (P) – potassium (K) through prilled urea, single super phosphate and muriate of potash. Entire P and K fertilizers were applied in last puddling. Nitrogen was top dressed in 3 equal splits at 5, 25 and 45 DAT during 2016. Thus entire N was scheduled for fodder crop only in 60 and 75 DAT FHTs, while $\frac{1}{3}$ N was scheduled to grain crop in 30 and 45 DAT FHTs. Looking at the poor performance of grain crop due to no N fertilizer application after FH in 60 and 75 DAT treatments, N application was rescheduled to grain crop during 2017. First N split was applied at 5 DAT (used by fodder crop), second and third splits were applied immediately and 20 days after FH. Rice crop received supplemental irrigation to maintain a water level of 5 cm from 3rd DAT. A rainfall of 228.8 and 179.2 cm was received in 70 and 93 days during 2016 and 2017 crop cycle. Two hand weedings were done at 25 and 45 DAT to manage weeds. Rice crop was harvested for grain on 15th January during both the years.

Rice crop was harvested for fodder at 5 cm above the ground level. Plant height and number of tillers/hill were recorded for 5 selected hills. Biomass harvested from each treatment was weighted and reported as green fodder yield, GFY (kg/plot). GFY of five observation hills was dried at 60°C for 48 hr in oven and dry weight was recorded. The ratio of dry to GF weight so obtained was used to convert the GFY into dry fodder yield, DFY (kg/plot) and into t/ha.

Nitrogen concentration of dry fodder was estimated as per Singh *et al.* (2005) and the crude protein (CP) content (%) was estimated by multiplying N concentration of fodder with 6.25. Crude protein yield, CPY (t/ha) was estimated as a product of CP content (%) and DFY (t/ha). Rice crop regrowth after FH was managed for grain production and plant height at harvest, yield attributes, biological yield, grain yield and harvest index were recorded as per standard procedures. Grain crop lodging was recorded from two 1 m² quadrat area in central rows of plot a week prior to harvest. Lodging (%) was worked out as ratio of number of standing hills to that of total hills/m² × 100. Plants with stems falling on the ground were taken as lodged ones while the plants with standing tillers above the ground were taken as non-lodged ones. Economics were worked out using input costs and output prices. System productivity as rice equivalent yield (REY) was estimated as a product of economic product yield (dry fodder, grain and straw, t/ha) and their price (₹/t). Total income arrived from the fodder, grain + straw yields was divided by the price of rice grain and reported as REY.

Analysis of variance was done for all the information generated in RBD. For fodder crop, 2 micro plots data of 2016 were also considered and thus 4 treatments (excluding no FH control) and 4 replications data was analysed and presented for both the years. However, for grain data and economics, normal size plots data (3 treatments with 7 replications in 2016 and 5 treatments with 4 replications in 2017) only was analysed and presented. The significance of treatment differences was compared by critical difference at 5% level of significance (P=0.05) and statistical interpretation of treatments was done as per Gomez and Gomez (1988).

RESULTS AND DISCUSSION

Fodder

Growth, yield and quality: Plant height (cm) and number of tillers/ hill of rice crop increased significantly with age of rice crop at harvest with highest values in 75 DAT and 60 DAT FHTs, respectively (Table 1). The analysis of data revealed that plant height gains (cm/day) by rice crop showed a decreasing trend with time. This was evident from the fact that rice crop has gained 3.20, 2.81, 2.75 and 2.59

Table 1 Growth attributes, fodder yield of rice and its quality as influenced by fodder harvest schedule

Fodder harvest at	Plant height (cm) at fodder harvest		Tiller number/ m ²		Green fodder yield (t/ha)		Dry fodder yield (t/ha)		Mean N content (%) of fodder	Mean crude protein yield (t/ha)
	2016	2017	2016	2017	2016	2017	2016	2017	Pooled	Pooled
30 DAT	97.8	93.3	9.85	9.25	7.05	6.23	1.80	1.74	2.00	0.221
45 DAT	123.6	118.9	13.70	13.95	11.83	11.82	3.19	3.37	1.70	0.349
60 DAT	163.1	173.7	16.80	17.50	15.68	17.28	4.52	5.06	1.53	0.458
75 DAT	188.3	199.4	14.60	15.25	20.71	22.90	5.95	6.64	1.39	0.538
SEm±	3.11	3.21	0.600	0.486	0.39	0.68	0.15	0.194	0.0257	0.00338
CD (P=0.05)	9.95	10.27	1.919	1.555	1.248	2.175	0.480	0.62	0.082	0.0108

cm height/day during 0-30, 30-45, 45-60 and 60-75 days' period. Tiller numbers showed a significant increase up to 60 DAT and there after showed a marked decline. The decline in tiller number after 60 DAT was ascribed to the mortality and drying up of the early formed tillers. The increases in plant height up to 75 DAT and tiller number up to 60 DAT FHTs together have brought marked increases in fodder production with 75 DAT FHT producing highest green (21.81 t/ha) and dry fodder (6.30 t/ha) on mean basis. The increases in plant height (26.0 cm) offsetting the decrease in tiller number (2.22/hill) in 75 DAT FHT has resulted in significantly higher fodder yields than that with 60 DAT FHT. A similar increase in fodder production of deep water rice taken from the collar of upper most leaf at different duration after planting by Sharma and De (1994) supports the current investigation findings.

Mean N concentration (%) of fodder decreased while CPY (t/ha) increased significantly as the age of rice crop at FH increased from 30 to 75 DAT. N concentration of rice fodder decreased by 0.61% whereas CPY increased by 0.317 t/ha between 30 and 75 DAT FHTs. The increase in CPY despite of a decrease in N concentration with age of rice crop at FH was ascribed to the greater increases in fodder production as compared to the decreases in N concentration.

Grain crop

Growth, panicles/m², yield and economics of rice: Plant height, panicles/m², grain, biological yield of rice and economics of fodder cum grain dual harvest system and its system productivity expressed as rice equivalent yield (REY) as influenced by FHTs were given in Table 2. The data reveals that plant height was reduced significantly due to fodder harvest as compared to no FH. Accordingly, the no FHT had produced significantly taller plants than 45 DAT FH. Plant height recorded in 30 and 45 DAT and 60 and 75 DAT FHTs were found at par with each other during both the years. Further, 60 DAT FHT has at par plant heights as that of 75 and 45 DAT FHT during both the years. In general, 2017 has produced taller grain crop plants than 2016 due to N fertilization of grain crop in 2017 in contrast to no N (60 and 75 DAT) $\frac{1}{3}$ N fertilization (30 and 45 DAT) of grain crop of 2016.

Panicle production/m² has shown different trend in each year on account of N management practices. During 2016, no FH control being at par with 30 DAT FHT produced significantly higher panicles/m² than that with 45 DAT FHT and 45 to 75 DAT FHTs have at par panicle production. On the contrary, during 2017, all FHTs except 75 DAT have recorded significantly higher panicle production than no FHT. Panicle number was highest in 30 DAT FHT. Fodder harvests irrespective of its time have increased the tillering in regrowth crop raised for grain production. These tillers successfully became panicles when N fertilization (two splits) was scheduled after FH in 2017. However, during 2016, N fertilization was given to fodder crop only (completed by 45 DAT), hence have less panicle production as compared to no FH. Further, when FH was taken early

(30 and 45 DAT), all the tillers produced have enough time to transform into panicles. Accordingly, in treatments where FH was delayed (60 - 75 DAT), many late produced tillers failed to become panicles. Number of grains/panicle (105-110) and their test weight (25.2 g) of rice did not differ due to FHTs during both the years.

Grain yield during 2016, did not differ due to FHTs though no FHT has higher yields. However, during 2017, 30 and 45 DAT FHTs being at par with each other have recorded significantly higher grain yields than no and 75 DAT FHTs. Nitrogen fertilization of fodder harvested grain crop during 2017 has improved the grain productivity as compared to no FH crop and the increases were significant in 30-45 DAT FHTs. Further grain yields in 60 and 75 DAT FHTs were at par with that of no FHT. Similar non-significant impacts of lopping of top leaves for fodder on grain yield of flood tolerant rice varieties were reported by Sharma and De (1994). Biological yield (BY) on pooled basis was highest in no FHT (11.77 t/ha). Fodder harvested rice crop has registered reductions in BY with lowest yields in 75 DAT FHT. Fodder harvest at 30 DAT has at par BY as that of no FHT. Further, the BY of 75 DAT FHT were significantly lower than that of 30 DAT FHT. System productivity estimated as REY (t/ha) were significantly higher in FHTs than no FH control (3.23 t/ha). Fodder harvest at 75 DAT recorded significantly higher REY (4.23 t/ha) followed by 60 (3.96 t/ha), 45 (3.89 t/ha) and 30 DAT FHTs (3.72 t/ha).

Economics data indicated that fodder cum grain harvest system with 1.77 times more net income to grain production alone (₹ 9446/ha). Further, net income was significantly higher with 75 DAT FHT than all other FHTs. Higher fodder yields coupled with at par grain yields of 75 DAT FHT as that of no FH control has resulted in higher net incomes.

Impacts of fodder harvest on grain crop lodging in rice: Rice crop devoid of FH has lodged completely that got reduced when FH was taken prior to grain production (Fig 1). On average, 30, 45, 60 and 75 DAT FHTs owing to the altered plant height and tiller strength have reduced the grain crop lodging by 14, 42.5, 54 and 71%. Rice crop devoid of FH has attained a mean height of 224.8 cm (Table 2) that was reduced by 11.5, 16.7, 26.2 and 36.8 cm in 30, 45, 60 and 75 DAT FHTs. These reductions in plant height of grain crop due to FH was significant only in 45 and 75 DAT treatments as compared to no FH and 45 DAT FHT, respectively during both the years. Rice plants in no FHT have attained a height of 1.65 m (Table 1) by third week of September as evident from plant height values of 60 DAT FHT. This crop increasing its height and biomass over time till harvest (165 days' main field duration) passed through the heavy rains of September - January has lodged completely by November. In contrast, when rice crop was harvested for fodder, the new growth started in first week of September (30 DAT FHT)- Mid of October (75 DAT FHT) that has reduced the main field crop duration to 135, 120, 105 and 90 days in 30, 45, 60 and 75 DAT FHTs. The gradual put up of regrowth of rice crop after FH (plant

Table 2 Growth, panicles/m², yield and economics* of rice as influenced by fodder harvest schedules

Fodder harvest at	Plant height (cm)		Panicle number /m ²		Grains yield (t/ha)		Biological yield (t/ha)	System yield (t/ha)**	Cost of cultivation (₹/ha)	Net income (₹/ha)
	2016	2017	2016	2017	2016	2017	Pooled	Pooled	Pooled	Pooled
30 DAT	207.9	218.6	312.0	302.5	2.51	2.14	10.90	3.72	40784	15042
45 DAT	200.7	215.4	296.0	290.0	2.35	2.00	10.07	3.89	42157	16280
60 DAT	194.6	202.6	287.8	285.0	2.11	1.90	9.25	3.96	43601	16697
75 DAT	185.0	191.0	278.1	272.5	1.98	1.79	8.76	4.23	45089	19088
Control	219.5	230.0	322.2	255.0	2.68	1.74	11.77	3.23	39025	9446
SEM±	4.10	4.24	6.01	6.20	0.101	0.075	0.45	0.058	-	321
CD (P=0.05)	12.57	13.00	18.52	19.10	NS	0.23	1.39	0.18	-	989

*Output price (₹/t): Grain: 15100; straw (1600); dry fodder (4000); ** Rice equivalent yield (REY)

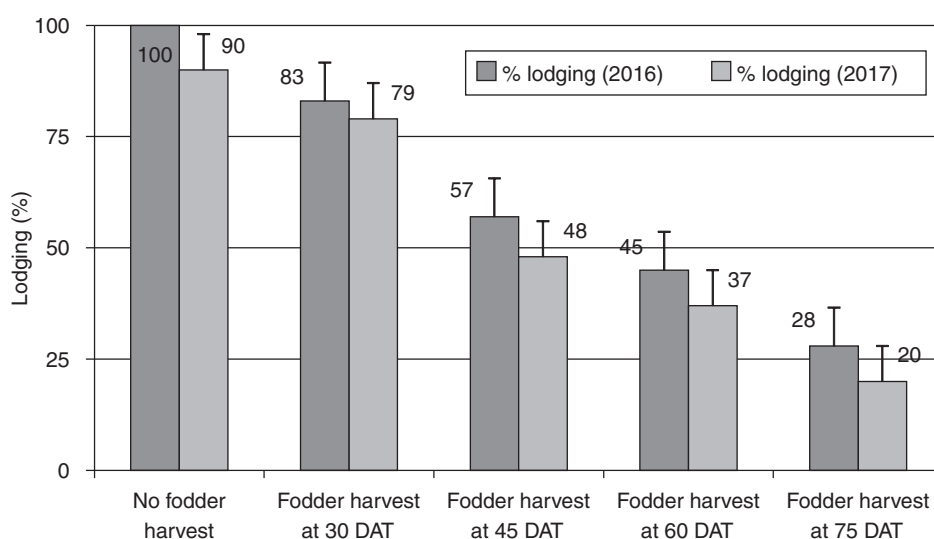


Fig 1 Impact of fodder harvest on rice crop lodging (%) (bars indicate CD values).

height, tillers and biomass) in less rainy months (October onwards) has made the crop to suffer less from lodging. More crop lodging was recorded in 2016 than 2017 due to high rainfall in September and December months in 2016. Similar rain quantity and intensity dependent lodging of rice crop were reported by Back *et al.* (1998).

Best yields and net returns from fodder cum grain dual harvest system from tall, long duration, photo-sensitive C-14-8 rice were realised with fodder harvest at 75 days after transplanting and managing the regrowth for grain production. Fodder harvest was quite effective in curtailing the lodging menace of grain crop and improving its performance.

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