

Research paper

Effect of Sali rice-relay system on growth and yield of succeeding fodder maize + green gram intercropping system in rice-fallows of Assam

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ABSTRACT

A field experiment was conducted to evaluate the effect of the Sali rice-relay system on the growth and yield of fodder maize + green gram intercropping during summer. The treatments comprised three dates of rice transplanting with four relay crops lentil, pea, toria, and niger. Significantly higher values of green fodder yield of maize were recorded when summer intercrops were grown after rice-lentil (205 and 196 q/ha in both the years) and rice-pea (198 and 189 q/ha in both the years) relay sequence as compared to rice-toria and rice-niger system. However, a significantly higher number of pods/plants, seed yield, and stover yield of green gram were found after the rice-toria and rice-niger relay sequence as compared to that of the rice-lentil and rice-pea systems. The effect of relay crops was also found significant on REY of fodder maize and green gram. The highest value of REY of maize fodder was found after the rice-lentil (16 q/ha) and rice-pea (15.42 q/ha) relay sequence, while the highest values of REY of green gram was recorded after rice-toria (37.26 q/ha) and rice-niger (37.02 q/ha).

Key words: Date of transplanting, Method of cultivation, Relay crop, Rice, Rice-fallows, Rice equivalent yield

INTRODUCTION

Rice (*Oryza sativa* L.) is the main staple food crop in Assam, occupying the first position for both area and production (Anonymous, 2014). Along with rice, pulses and oilseeds are also important food crops. In 2020-21, the total rice production in Assam state was about 5.21 mt from an area of 2.4 m ha, but production of oilseeds and pulses was 0.20 and 0.11 mt from 0.33 and 0.14 m ha, respectively (Anonymous, 2022). Although Assam state has achieved self-sufficiency in rice production, it is always efficient in pulses and oilseed production. So, the production of pulses and oilseeds also needs special attention to meet their requirement for the burgeoning population. Due to increasing population pressure, the demand for food, fodder, fuel, pulses, and oilseed products is increasing day by day (Vidyavathi *et al.*, 2011).

To increase their production, intensification of pulses and oilseeds through multiple cropping in rice fallows of Assam is of prime importance (Deka *et al.*, 2013). In Assam, since rice crop covers a major area under cultivation, rice lands are the only target for intensification of different crops. It is of utmost importance to have better planning, resource management as well as crop intensification

to increase food and feed production to meet future demands. Therefore, the present study aimed to assess food and feed production and also to maximize the production of a rice-based system involving pulses, oilseeds, and maize fodder.

MATERIALS AND METHODS

A field experiment was conducted during the *kharif*, *rabi*, and summer seasons of 2018-19 and 2019-20 in three crop sequences at the Zonal Research Station of Assam Agricultural University, Shillongani, Assam (situated at a latitude of 26° N, longitude of 90°45' E, and an altitude of 50.2 m above the mean sea level). The climate of the study site was sub-tropical with a hot humid summer and a relatively dry and cold winter. During the crop growth period, the amount of total rainfall was 1383 mm in 2018-19 and 1631 mm in 2019-20. The soil of the experimental field was sandy loam with pH 5.56, high in organic carbon (0.80 %), medium in available N (298 kg/ha), and low in P₂O₅ (20 kg/ha) and K₂O (197 kg/ha). The experiment was laid out in a factorial randomized block design for the treatments in rice during the *kharif* season and a split-plot design for treatments of relay crops in the *rabi* season assigning dates of planting and method

of cultivation in the main plots and relay crops in subplots with three replications. During summer, fodder maize and green gram were grown as intercrop in each plot in 1:1 row ratio. All the crops were fed with recommended doses of fertilizers. Winter rice variety 'Ranjit', lentil variety 'PL 406', pea var 'Aman', toria var. 'TS 38', niger var. 'NG 1', greengram var. 'Pratap' and fodder maize var. 'African Tall' was grown for the study. The seeds of all the *rabi* crops *viz.*, lentil, pea, *toria*, and niger were broadcasted @ 45 kg/ha, 80 kg/ha, 13 kg/ha, and 16 kg/ha, respectively, in the standing rice crop at soil moisture saturation condition. All the crops were harvested at their physiological maturity stage.

For maize fodder yield, the plants of each plot were harvested at 60 days of crop growth and then the fresh weight of all plants/plots was taken as fodder yield in kg/plot and then converted into q/ha. In the case of green gram, pods picked from the plants in each plot area were threshed and weighed. The yield per hectare was worked out based on gross plot yield and expressed in quintals per hectare (q/ha).

Rice equivalent yield (REY) of intercrops

The REY of summer inter-crops was calculated by using the following formula.

$$\text{REY} = \frac{\text{Yield of summer intercrop (q/ha)} \times \text{price of summer intercrop (INR/q)}}{\text{Price of rice (INR/q)}}$$

Statistical analysis

The data about each of the characters of the experimental crops were tabulated and finally analyzed statistically as per the procedure prescribed for Factorial RBD as well as the Split Plot Design described by Panse and Sukhatme (1985). The significance or non-significance of the variances due to treatment effects was tested by the 'F' test. The critical difference was calculated whenever the 'F' test was significant.

RESULTS AND DISCUSSION

Maize

Plant height

The effect of transplanting dates was not significant on the plant height in fodder maize at harvest during both years. However, rice cultivation methods had a significant effect on plant

height of fodder maize at harvest during 2018-19. Significantly higher plant height of fodder maize was found under SRI over conventional methods of rice cultivation. Relay crops had a significant effect on the plant height of fodder maize during both years (Table 1). Fodder maize grown after lentils recorded significantly higher plant height and it was statistically at par with that observed after pea. However, the reduced plant height of fodder maize was found when it was grown after the relay crop of *toria* (207.94 cm and 198.07 cm in 2018-19 and 2019-20, respectively) and niger. The higher plant height of fodder maize grown after lentil and pea relay crops might be due to the beneficial effect of these two leguminous crops on the improvement of soil fertility. Our results are also in conformity with the findings of Kumar *et al.* (1998), Iderawumi (2014), Anonymous (2015), and Matusso *et al.* (2014).

Green fodder yield

Relay crops had also a significant effect on the green fodder yield of maize during both years. The maximum green fodder yield of maize was noted when it was grown after lentil and it was at par with pea. It was significantly higher than that grown after *toria* and niger during 2018-19. However, it was at par with pea and *toria* and significantly higher than that grown after niger during 2019-20. This might be attributed to higher plant height and better crop growth of fodder maize grown after lentil and pea relay crops. Similar findings were also reported by Matusso *et al.* (2014), Manasa *et al.* (2018) and Maitra *et al.* (2020). The interaction effect among different dates of transplanting and methods of rice cultivation as well as relay crops on green fodder yield of maize was found statistically non-significant.

Green gram

Growth attributes

The date of rice transplanting, method of rice cultivation, and relay crops had no significant effect on plant height, number of primary and secondary branches/plant in green gram at harvest during both years (Table 2).

Yield attributes

Dates of transplanting and methods of rice cultivation showed no significant effect on the number of pods/plant and seeds/pod in green gram in both years. However, the number of pods/plant

Table 1. Plant height and green fodder yield of fodder maize in the intercropping system as influenced by different treatments

Treatment	Plant height (cm)		Green fodder yield (q/ha)	
	2018-19	2019-20	2018-19	2019-20
<i>Date of rice transplanting (D)</i>				
D ₁ : 20 th June	211.43	201.77	197.75	190.70
D ₂ : 5 th July	210.87	201.05	196.70	189.62
D ₃ : 20 th July	209.30	199.81	195.40	189.81
SEm±	0.74	1.32	2.24	2.30
CD (P=0.05)	NS	NS	NS	NS
<i>Method of rice cultivation (M)</i>				
M ₁ : Conventional	209.45	199.84	194.60	189.01
M ₂ : SRI	211.62	201.92	198.64	191.08
SEm±	0.60	1.08	1.82	1.88
CD (P=0.05)	1.90	NS	NS	NS
<i>Relay crops (C)</i>				
C ₁ : Lentil	213.43	203.92	204.57	196.33
C ₂ : Pea	212.32	203.09	197.97	189.37
C ₃ : Toria	207.94	198.07	194.05	189.22
C ₄ : Niger	208.46	198.43	189.88	185.25
SEm±	0.81	1.36	2.55	2.24
CD (P=0.05)	2.34	3.92	7.34	6.43
<i>Interactions</i>				
D×M	NS	NS	NS	NS
D×C	NS	NS	NS	NS
M×C	NS	NS	NS	NS
D×M×C	NS	NS	NS	NS
C.V. (%)	5.84	6.45	8.74	8.00

Table 2. Plant height (cm), primary and secondary branches/plant of green gram in the intercropping system as influenced by different treatments

Treatment	Plant height (cm)		No. of primary branches/plant		No. of secondary branches/plant	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
<i>Date of rice transplanting (D)</i>						
D ₁ : 20 th June	83.93	79.76	3.4	3.3	10.4	9.5
D ₂ : 5 th July	83.86	79.70	3.3	3.3	10.4	9.4
D ₃ : 20 th July	82.23	78.41	3.2	3.1	10.2	9.3
SEm±	1.20	0.89	0.09	0.07	0.12	0.16
CD (P=0.05)	NS	NS	NS	NS	NS	NS
<i>Method of rice cultivation (M)</i>						
M ₁ : Conventional	83.27	79.10	3.3	3.2	10.3	9.4
M ₂ : SRI	83.41	79.48	3.3	3.2	10.3	9.4
SEm±	1.04	0.72	0.07	0.06	0.10	0.13
CD (P=0.05)	NS	NS	NS	NS	NS	NS
<i>Relay crops (C)</i>						
C ₁ : Lentil	83.49	79.50	3.3	3.2	10.3	9.3
C ₂ : Pea	82.55	78.71	3.3	3.2	10.2	9.2
C ₃ : Toria	83.56	79.99	3.3	3.3	10.5	9.6
C ₄ : Niger	83.76	78.95	3.31	3.3	10.4	9.4
SEm±	1.39	1.37	0.12	0.13	0.17	0.20
CD (P=0.05)	NS	NS	NS	NS	NS	NS
<i>Interactions</i>						
D x M	NS	NS	NS	NS	NS	NS
D x C	NS	NS	NS	NS	NS	NS
M x C	NS	NS	NS	NS	NS	NS
D x M x C	NS	NS	NS	NS	NS	NS
C.V. (%)	6.28	5.91	14.66	15.11	7.39	9.23

and seeds/pod in green gram differed significantly due to different relay crops in both years (Table 3). A higher number of pods/plant and seeds per pod of green gram were recorded when this crop was grown after toria and niger compared to lentil and pea during both years in the present study. This might be due to the early sowing of green gram after toria and niger as compared to lentil and pea because of the shorter crop durations of these two *rabi* crops. This might have helped green gram for early establishment and better growth. Similar results were also reported by Manasa *et al.* (2018) and Maitra *et al.* (2020).

Seed and stover yield

Relay crops had a significant effect on seed and stover yield in green gram during both years (Table 4). The highest seed yield of green gram was recorded when this crop was grown after toria which was at par with that after niger and both were significantly higher than after lentil and pea in both the years. The higher grain yield of green gram after toria and niger was due to early sowing of green gram, early crop establishment, and better crop growth which

resulted in better yield attributes, early as well as complete picking of green gram pods and thereby resulted in higher seed yield of green gram. While sowing of green gram was delayed due to the late harvest of lentil and pea which resulted in delayed picking of pods and coincidence with pre-monsoon rainfall during the later crop growth stage resulting in poor seed formation and ultimately lower yield during both years. The higher stover yield of green gram was recorded when this crop was grown after toria and niger crops as compared to lentil and pea relay crops. A similar result was reported by Manasa *et al.* (2018).

Rice equivalent yield (REY)

The REY of fodder maize differed significantly due to different relay crops in 2019-20 and did not differ significantly in 2018-19 (Table 5). In 2019-20, the highest REY of fodder maize was recorded when it was grown after lentil which was significantly higher than REY of fodder maize grown after pea, *toria*, and niger. The REY of fodder maize after lentil might be due to the beneficial effect of lentil on maize fodder which resulted in better growth and

Table 3. Pods/plant, seed/pod, and 1000- seed weight of green gram in the intercropping system as influenced by different treatments

Treatment	Number of pods/ plant		Seed/pod		1000- seed weight (g)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Date of rice transplanting (D)						
D ₁ : 20 th June	53.6	49.4	11.5	11.0	29.8	29.8
D ₂ : 5 th July	51.9	47.6	11.3	10.8	29.8	29.8
D ₃ : 20 th July	47.1	44.1	10.9	10.3	29.6	29.7
SEm±	2.74	2.10	0.44	0.35	0.15	0.14
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Method of rice cultivation (M)						
M ₁ : Conventional	50.0	46.1	11.2	10.6	29.7	29.7
M ₂ : SRI	51.7	48.0	11.3	10.8	29.8	29.7
SEm±	2.24	1.71	0.36	0.28	0.12	0.12
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Relay crops (C)						
C ₁ : Lentil	49.9	45.2	11.2	10.6	29.7	29.7
C ₂ : Pea	47.2	42.9	11.1	10.5	29.8	29.7
C ₃ : Toria	54.5	51.9	11.3	10.9	29.8	29.8
C ₄ : Niger	51.8	48.0	11.3	10.8	29.7	29.7
SEm±	1.07	1.01	0.05	0.05	0.10	0.09
CD (P=0.05)	3.09	2.92	0.14	0.14	NS	NS
Interactions						
D x M	NS	NS	NS	NS	NS	NS
D x C	NS	NS	NS	NS	NS	NS
M x C	NS	NS	NS	NS	NS	NS
D x M x C	NS	NS	NS	NS	NS	NS
C.V. (%)	13.90	15.28	9.97	9.17	5.52	5.49

Table 4. Seed yield, stover yield and harvest index of green gram in the intercropping system as influenced by different treatments

Treatment	Seed yield (q/ha)		Stover yield (q/ha)		Harvest index (%)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
<i>Date of rice transplanting (D)</i>						
D ₁ : 20 th June	6.34	6.15	14.75	15.02	30.05	29.05
D ₂ : 5 th July	6.32	6.14	14.81	15.22	29.90	28.83
D ₃ : 20 th July	6.23	6.01	14.64	14.92	29.87	28.77
SEm±	0.06	0.05	0.16	0.42	0.27	0.53
CD (P=0.05)	NS	NS	NS	NS	NS	NS
<i>Method of rice cultivation (M)</i>						
M ₁ : Conventional	6.28	6.09	14.67	15.00	29.96	28.90
M ₂ : SRI method	6.32	6.11	14.80	15.10	29.92	28.86
SEm±	0.05	0.04	0.13	0.34	0.22	0.43
CD (P=0.05)	NS	NS	NS	NS	NS	NS
<i>Relay crops (C)</i>						
C ₁ : Lentil	5.87	5.70	14.06	14.48	29.47	28.34
C ₂ : Pea	5.85	5.67	14.04	14.21	29.43	28.54
C ₃ : Toria	6.74	6.55	15.54	15.86	30.26	29.31
C ₄ : Niger	6.73	6.48	15.27	15.66	30.60	29.33
SEm±	0.08	0.07	0.14	0.27	0.40	0.45
CD (P=0.05)	0.24	0.22	0.42	0.78	NS	NS
<i>Interactions</i>						
D x M	NS	NS	NS	NS	NS	NS
D x C	NS	NS	NS	NS	NS	NS
M x C	NS	NS	NS	NS	NS	NS
D x M x C	NS	NS	NS	NS	NS	NS
C.V. (%)	8.54	8.37	6.45	9.39	5.73	6.76

Table 5. Rice equivalent yield (REY) of fodder maize and green gram (q/ha) in inter cropping system as influenced by different treatments

Treatment	REY of fodder maize (q/ha)			REY of green gram (q/ha)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
<i>Date of rice transplanting (D)</i>						
D ₁ : 20 th June	15.74	15.26	15.54	35.41	34.41	34.91
D ₂ : 5 th July	15.82	15.17	15.40	35.53	34.46	34.99
D ₃ : 20 th July	15.63	15.18	15.27	34.94	33.70	34.32
SEm±	1.08	0.18	0.13	0.38	0.32	0.28
CD (P=0.05)	NS	NS	NS	NS	NS	NS
<i>Method of rice cultivation (M)</i>						
M ₁ : Conventional	15.57	15.12	15.27	35.19	34.12	34.65
M ₂ : SRI	15.89	15.29	15.54	35.40	34.27	34.83
SEm±	0.88	0.15	0.10	0.31	0.26	0.23
CD (P=0.05)	NS	NS	NS	NS	NS	NS
<i>Relay crops (C)</i>						
C ₁ : Lentil	16.36	15.70	16.00	32.89	31.93	32.41
C ₂ : Pea	15.84	15.15	15.42	32.78	31.78	32.28
C ₃ : Toria	15.52	15.14	15.36	37.78	36.73	37.26
C ₄ : Niger	15.19	14.82	14.84	37.71	36.32	37.02
SEm±	1.04	0.17	0.11	0.48	0.45	0.40
CD (P=0.05)	NS	0.51	0.31	1.37	1.28	1.15
<i>Interactions</i>						
Dx x M	NS	NS	NS	NS	NS	NS
Dx x C	NS	NS	NS	NS	NS	NS
Mx x C	NS	NS	NS	NS	NS	NS
Dx x M x C	NS	NS	*	NS	NS	NS
C.V. (%)	6.23	6.85	6.50	8.54	8.38	8.37

* = Significant

development and thereby higher green fodder yield of maize. Similar findings were also reported by Matusso *et al.* (2014).

The REY of green gram differed significantly due to different relay crops in both years (Table 5). The highest REY of green gram was recorded when this crop was grown after toria and that was closely followed by green gram grown after niger and they were at par and both were significantly higher than REY of green gram grown after lentil and pea during both the years. The higher REY of green gram with toria and niger was due to higher green gram yield, a result of early sowing of green gram after toria and niger as compared to lentil and pea, where sowing of green gram was delayed due to late harvesting of lentil and pea (Kumar *et al.*, 2015; Ahmed *et al.*, 2020).

CONCLUSION

The pulse and fodder maize intercropping during the summer season in the winter rice-relay cropping system is a new dimension of the study, which may contribute immensely towards proper utilization of rice fallow lands, nutritional security of human being and livestock as well as income and employment generation to farmers.

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