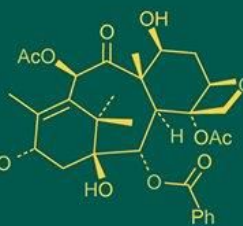
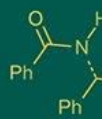


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating: 5.29
IJABR 2025; 9(5): 995-1002
www.biochemjournal.com
Received: 15-02-2025
Accepted: 18-03-2025

R Kalita
Associate Professor,
Department of Agronomy,
B.N. College of Agriculture,
AAU, Biswanath, Assam,
India

RK Thakuria
Director, Open & Distance
Learning, Assam Agricultural
University, Guwahati, Assam,
India

BK Medhi
Director, Directorate of
Students' Welfare, Assam
Agricultural University,
Jorhat, Assam, India

G Kalita
Department of Agronomy,
B.N. College of Agriculture,
AAU, Biswanath, Assam,
India

B Dutta
Department of Soil Science,
College of Agriculture, AAU,
Jorhat, Assam, India

S Kalita
Assistant Professor,
Department of Agronomy,
College of Agriculture, AAU,
Jorhat, Assam, India

Corresponding Author:
R Kalita
Associate Professor,
Department of Agronomy,
B.N. College of Agriculture,
AAU, Biswanath, Assam,
India

Optimized crop microenvironments for enhanced growth and physiological parameters of *kharif* paddy (*Oryza sativa* L.) in Assam

R Kalita, RK Thakuria, BK Medhi, G Kalita, B Dutta and S Kalita

DOI: <https://www.doi.org/10.33545/26174693.2025.v9.i5l.4458>

Abstract

A 2-year-long field experiment was conducted to study the effect of crop microenvironments on growth and physiological parameters of *kharif* paddy (*Oryza sativa* L.). The experiment incorporated two establishment methods-System of Rice Intensification (SRI) and Conventional Rice Cultivation (CRC), three transplanting dates (June 26th, July 10th, and July 25th) and four crop densities (20 cm × 15 cm, 20 cm × 20 cm, 25 cm × 20 cm, and 25 cm × 25 cm). The two years of comprehensive studies concluded that paddy cultivated under SRI consistently demonstrated clear advantages over CRC, including greater plant height and a higher number of tillers per square meter. Except for early stage, SRI recorded significantly higher LAI and chlorophyll content throughout the growth, the highest at flowering while CRC had the highest at maximum tillering stage (MTS). Likewise, early planting and wider spacing also scored higher magnitudes. Throughout the crop growth, SRI registered increased CGR while lower density of 25 cm × 25 cm had a higher value during the MTS to grain filling stage. During the initial vegetative stage, both SRI and wider spacing showed significantly higher RGR and NAR. Significantly superior growth and physiological parameters have been observed when the *kharif* paddy was transplanted early under SRI management with a crop density of 25 cm × 25 cm.

Keywords: Crop establishment technique, system of rice intensification, conventional rice cultivation, crop microenvironment, growth rate

Introduction

Rice (*Oryza sativa* L.) is the predominant cereal crop in Assam, occupying approximately 25.03 lakh hectares and contributing 51.93 lakh tons to the state's total food grain output. This represents 92.22% of Assam's overall food production, as reported in the Economic Survey of India (2017-18). Currently, the state maintains a rice-surplus status with an average productivity of 21 quintals per hectare. However, projections indicate that by 2050, Assam will require an estimated 130 lakh tons of rice to sustain its increasing population, ensure food security, and maintain self-sufficiency^[8]. To achieve the projected demand, the state must increase rice productivity to 40 quintals per hectare approximately twice the current yield, as outlined in "Vision 2050 - Agriculture in Assam" (2014). Enhancing *kharif* paddy productivity is vital for meeting future production targets, especially given the declining availability of arable land. Efficient utilization of land, water, nutrients, labor, and capital can be achieved through yield intensification, supporting sustainable agriculture and resource conservation while promoting crop diversification^[8]. Agronomic practices that modify the crop microenvironment-such as planting time, method, and crop density-play a crucial role in optimizing light interception^[4] and aligning crop growth with favorable temperature periods, thereby enhancing yield with lower input requirements^[3]. Adjusting planting density through strategic manipulation of spacing between plants and rows offers a viable approach to influencing plant population dynamics and canopy structure for improved productivity. SRI is such a practice that has demonstrated superior performance over traditional methods resulting in higher growth, yield and physiological parameters. The higher yields observed under SRI can be attributed to the strategic and timely application of agronomic practices that create a favorable microenvironment, allowing rice plants to reach their full genetic potential. Research shows that the lower planting density used in SRI improves air circulation within the crop canopy, which helps reduce humidity and lowers the

risk of pests and diseases, as a result of which rice plants grown under SRI tend to be healthier and more vigorous [8, 9].

In the light of these considerations, a field experiment was conducted in the Golaghat district of Assam during 2016 and 2017, with a medium-duration kharif paddy variety under medium land situation to identify the optimal microenvironmental conditions for improving the growth and physiological parameters of kharif paddy.

Materials and Methods

A field experiment was carried out during the kharif seasons of 2016 and 2017 at a farmer's field located in the Golaghat district of Upper Brahmaputra Valley Zone (UBVZ) of Assam. The experimental site featured sandy loam soil with an acidic pH, medium organic carbon content, and a well-drained profile. The region falls under a subtropical humid climate, characterized by high annual rainfall exceeding 2000 mm, relative humidity above 80%, and temperature fluctuations between 5°C and 37°C. During the experimental period (June to November), total rainfall amounted to 1242.6 mm in 2016 and 1618.8 mm in 2017, with rainfall distribution being uneven across both years. July recorded the highest monthly rainfall—342.1 mm in 2016 and 449.9 mm in 2017—coinciding with the tillering stage of the rice crop. The mean maximum temperature ranged from 27.8°C to 34.4°C in 2016 and from 27.9°C to 35.2°C in 2017, while mean minimum temperatures ranged from 16.4°C to 25.8°C and 19.1°C to 26.7°C in 2016 and 2017, respectively. The average weekly bright sunshine hours (BSSH) in the first year were 3.24 hours, varying between 0.5 and 6.8 hours. In contrast, the second year experienced longer sunshine durations, averaging 4.7 hours per week and ranging from 1.1 to 8.8 hours.

The experiment was laid out in a factorial split-plot design, incorporating two crop establishment methods: the SRI (C1) and CRC (C2). Three transplanting dates—26th June (D1), 10th July (D2), and 25th July (D3)—were assigned as main plot treatments. The subplots consisted of four crop density configurations: 20 cm × 15 cm (S1), 20 cm × 20 cm (S2), 25 cm × 20 cm (S3), and 25 cm × 25 cm (S4), corresponding to planting densities of 33, 25, 20, and 16 hills per square

meter, respectively. The high-yielding variety "Shraboni" was used for the experiment, where twelve-day-old seedlings were transplanted using the SRI method, whereas twenty-day-old seedlings were used for transplanting under the CRC method. All collected data were statistically analyzed using the analysis of variance (ANOVA) appropriate for a factorial split-plot design. Treatment means were compared at a 5% level of significance.

Results and Discussion

Influence on Plant height and number of tillers m⁻²

Table 1 presents data on plant height and number of tillers m⁻² as affected by microenvironmental variations resulting from different crop establishment methods, transplanting dates, and crop density levels. At flowering and physiological maturity, plants under the SRI exhibited significantly greater height compared to those under CRC methods. However, crop establishment methods failed to show any significant variation at maximum tillering stage (MTS). It was observed that SRI method consistently resulted in a higher number of tillers m⁻² throughout the growing period. This enhanced growth is likely due to the shallow transplanting of younger seedlings in SRI, which was promoted by extensive root development and nutrient uptake. The minimal disturbance to roots and buds during SRI transplanting may have further supported increased tiller emergence and plant height (Hosain *et al.*, 2018; Mohanty *et al.*, 2014) [6, 11] and nutrient uptake (Kalita *et al.*, 2024) [9].

Plant height remained unaffected by transplanting date across all growth stages. However, the number of tillers per m⁻² varied significantly. Early transplanting (26th June) resulted in the highest tiller count, followed by the 10th July and 25th July. At flowering and physiological maturity, the 26th June and 10th July plantings recorded statistically similar tiller numbers, reflecting the advantages of early transplanting, as also reported by Kalita *et al.* (2025); Sharma *et al.* (2011) and Sharma *et al.* (2018) [10, 14, 15]. Regarding crop density, wider spacing i.e., 16 hills m⁻² produced the tallest plants, comparable to 20 and 25 hills m⁻², while the closest spacing (33 hills m⁻²) resulted in significantly shorter plants.

Table 1: Plant height and number of tillers m⁻² of rice as influenced by crop establishment method, date of transplanting and crop density

Treatment	Plant height (cm)						Number of tillers m ⁻²					
	MTS		Flowering		Physiological maturity		MTS		Flowering		Physiological maturity	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Crop establishment												
SRI	104.95	106.93	122.05	122.64	123.91	124.28	302.16	311.57	314.20	318.50	289.90	302.83
CRC	103.37	104.83	120.19	120.84	122.07	122.47	229.00	237.88	244.24	249.18	219.62	279.48
S.Em±	0.92	0.91	0.31	0.48	0.58	0.54	3.52	3.09	3.73	4.68	3.31	4.33
CD (P=0.05)	NS	NS	0.98	1.51	1.82	1.72	11.10	9.74	11.76	14.76	10.43	13.64
Date of transplanting												
26th June	104.98	106.72	121.73	122.26	123.62	124.07	283.06	288.97	292.92	298.53	265.08	304.46
10th July	104.36	106.11	121.22	121.87	123.13	123.39	264.00	275.91	279.29	283.81	255.63	290.74
25 th July	103.14	104.82	120.41	121.08	122.22	122.66	249.70	259.29	265.45	269.18	243.58	278.26
S.Em±	1.13	1.11	0.38	0.59	0.71	0.67	4.31	3.78	4.57	5.73	4.05	5.30
CD (P=0.05)	NS	NS	NS	NS	NS	NS	13.60	11.93	14.41	18.07	12.77	16.70
Crop Density												
20 cm x 15 cm	101.04	102.77	119.27	119.78	120.95	121.47	249.98	258.50	265.19	271.33	238.32	257.29
20 cm x 20 cm	103.73	105.44	120.21	120.88	122.28	122.51	263.40	272.69	277.78	281.96	255.10	301.88
20 cm x 25 cm	105.57	107.25	122.11	122.71	123.93	124.41	276.67	285.92	288.89	294.08	263.71	304.42
25 cm x 25 cm	106.29	108.07	122.89	123.58	124.79	125.11	272.29	281.78	285.02	287.99	261.93	301.03
S.Em±	0.44	0.57	0.45	0.54	0.59	0.64	4.72	5.84	4.02	5.53	3.71	5.80
CD (P=0.05)	1.26	1.62	1.30	1.57	1.71	1.85	13.55	16.75	11.53	15.85	10.62	16.63

Note: MTS: maximum tillering stage; NS: Non-significant; S.Em: Standard error of mean; CD: critical difference

Influence on Leaf area and dry matter production

Analysis of leaf area per hill (Table 2) at various growth stages showed that crops grown under CRC method initially produced higher leaf area during the tillering stage. However, from MTS onwards, SRI crops exhibited significantly greater leaf area up to physiological maturity, highest being recorded at flowering in both years. Table 3 showed that in the 2nd year, the highest dry matter (DM) accumulation (62.34 g hill⁻¹) was recorded at PM, whereas in 2016, the peak (57.40 g hill⁻¹) occurred at flowering. Like leaf area, the lower accumulation of DM was also observed in the tillering stage of SRI crop as compared to CRC, likely due to reduced solar interception by the smaller canopy associated with fewer tillers of SRI crops during that stage. However, from MTS onward, dry matter accumulation in SRI increased steadily and substantially. These findings align with previous studies of Vijayakumar *et al.* (2006) [20] and Shantappa *et al.* (2014) [13], highlighting improved growth performance under SRI management.

Both leaf area and dry matter production per hill were significantly affected by transplanting date. Crops transplanted on 26th June recorded higher values compared to those planted on 10th and 25th July. In both years,

delayed transplanting up to 25th July led to a notable decline in these growth parameters, likely due to a shortened vegetative phase caused by elevated maximum temperatures and reduced rainfall. Weather conditions, especially maximum temperature and rainfall, had a significant impact on the growth of the paddy crop, aligning with findings of Jayapriya *et al.* (2016) and Kalita *et al.* (2023) [7, 8].

Crops spaced at 16 hills m⁻² produced the highest leaf area at flowering. Reducing crop density consistently increased leaf area in both years, with the lowest density of 16 hills m⁻² yielding the highest values, followed by 20, 25, and 33 hills m⁻². Throughout the crop growing stages, maximum value of DM production per hill was recorded in lowest crop density which was observed to be at par with its immediate higher i.e. 20 hills m⁻² from MTS onwards, however, crop density of 25 hills m⁻² produced comparable DM in all except 33 hills m⁻² in the tillering stage. Lower level of intra-specific competition in widely spaced crops likely enhanced resource availability to the plants, promoting tillering, leaf area expansion, and eventually dry matter. These findings are consistent with the observations of Chakraborty *et al.* (2014); Kalita *et al.* (2023) and Kalita *et al.* (2024) [2, 8, 9].

Table 2: Leaf area (cm²hill⁻¹) throughout growth stages as influenced by modified crop microenvironments

Treatments	Tillering		MTS		Flowering		Maturity	
	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr
Crop establishment								
SRI	560.86	571.03	2948.05	2944.93	2994.64	3025.72	1011.13	1044.95
Conventional	1424.69	1551.84	2587.83	2631.17	2681.70	2709.85	630.43	651.83
S.Em±	19.93	14.83	18.66	29.65	23.42	24.90	15.46	12.54
CD (P=0.05)	62.82	46.72	58.79	93.42	73.81	78.48	48.73	39.51
Date of transplanting								
26th June	1045.96	1117.28	2878.21	2871.14	2931.04	2955.90	887.69	917.55
10th July	1009.36	1064.23	2777.23	2797.01	2854.93	2866.07	829.82	857.55
25th July	923.01	1002.79	2648.39	2696.00	2718.54	2781.38	744.83	770.06
S.Em±	24.42	18.16	33.09	29.24	31.52	30.50	18.94	19.60
CD (P=0.05)	76.93	57.22	104.28	92.13	99.31	96.11	59.69	61.76
Crop density								
20 cm x 15 cm	671.11	708.33	1707.50	1738.50	1778.17	1782.67	434.17	448.67
20 cm x 20 cm	900.89	944.22	2374.89	2370.22	2422.22	2450.89	648.89	673.78
20 cm x 25 cm	1136.11	1158.06	3085.56	3098.33	3142.22	3190.00	941.39	978.06
25 cm x 25 cm	1263.00	1435.13	3903.82	3945.14	4010.07	4047.57	1258.68	1293.06
S.Em±	35.45	20.29	44.92	27.03	34.45	32.36	19.49	19.19
CD (P=0.05)	101.67	58.20	128.83	77.52	98.81	92.80	55.92	55.04

Note: MTS: maximum tillering stage; S.Em: Standard error of mean; CD: critical difference

Table 3: Dry matter production (g hill⁻¹) at various growth stages as influenced by modified crop microenvironments

Treatments	Tillering		MTS		Flowering		Maturity	
	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr
Crop establishment								
SRI	13.01	14.61	50.86	53.89	57.40	59.77	53.04	62.34
Conventional	21.69	24.23	45.86	48.98	50.98	54.21	45.52	54.10
S.Em±	0.48	0.52	0.72	0.71	0.68	0.71	0.66	0.71
CD (P=0.05)	1.52	1.62	2.27	2.25	2.13	2.24	2.10	2.23
Date of transplanting								
26th June	19.33	21.17	50.62	53.53	56.37	59.04	51.66	60.99
10th July	17.43	19.46	48.95	52.12	54.34	57.45	49.75	58.48
25th July	15.28	17.63	45.52	48.65	51.88	54.49	46.43	55.19
S.Em±	0.63	0.57	0.88	0.88	0.83	0.87	0.81	0.87
CD (P=0.05)	1.98	1.80	2.78	2.76	2.61	2.74	2.57	2.73
Crop density								
20 cm x 15 cm	15.14	17.43	30.82	34.51	35.75	37.18	33.24	36.08
20 cm x 20 cm	17.32	19.29	45.94	47.57	49.66	53.22	44.27	53.8
20 cm x 25 cm	18.45	20.44	57.29	60.89	64.55	67.42	58.54	70.00
25 cm x 25 cm	18.49	20.53	59.40	62.77	66.81	70.15	61.07	73.00
S.Em±	0.64	0.64	1.18	1.23	1.13	1.23	1.19	1.12
CD (P=0.05)	1.82	1.84	3.39	3.53	3.24	3.52	3.40	3.22

Note: MTS: maximum tillering stage; S.Em: Standard error of mean; CD: critical difference;

Influence on Physiological Parameters

Crop growth rate (CGR)

The crop growth rate (CGR) was measured at different stages of development: 25-50 DAT, 50-75 DAT, 75-100 DAT, and from 100 DAT to physiological maturity. Across all microenvironmental conditions, CGR exhibited a progressive increase with crop development, reaching its maximum during the 75-100 DAT. Subsequently, a decline in CGR was observed as the crop approached physiological maturity (Figures 1 and 2).

The method of crop establishment significantly influenced CGR throughout the growth period in both years, with the highest values of 17.34 and 17.00 $\text{g m}^{-2} \text{d}^{-1}$ recorded during 75-100 DAT under the SRI method. The enhanced CGR in SRI is likely attributed to greater dry matter accumulation driven by factors such as increased tillering, facilitated by the shallow planting of younger seedlings and reduced intra-

specific competition. Conversely, date of transplanting failed to show any specific effect in terms of CGR at different crop growing stages, however, a reduction of CGR with the delay of transplanting date was observed. Crop density significantly influenced CGR during the later growth stages (75-100 DAT and 100 DAT to physiological maturity), though year-to-year differences were not statistically significant. In both 2016 and 2017, the highest CGR was recorded under the crop density of 16 hills m^{-2} , which was statistically comparable to 20 hills m^{-2} . This enhanced CGR at lower planting density might be attributed to a higher number of tillers and leaves per unit area, promoting greater photosynthate production, translocation, and accumulation during the mid-tillering to grain-filling stages. These findings are consistent with reports by Vijayakumar *et al.* (2006) ^[20] and Rajput *et al.* (2017) ^[12].

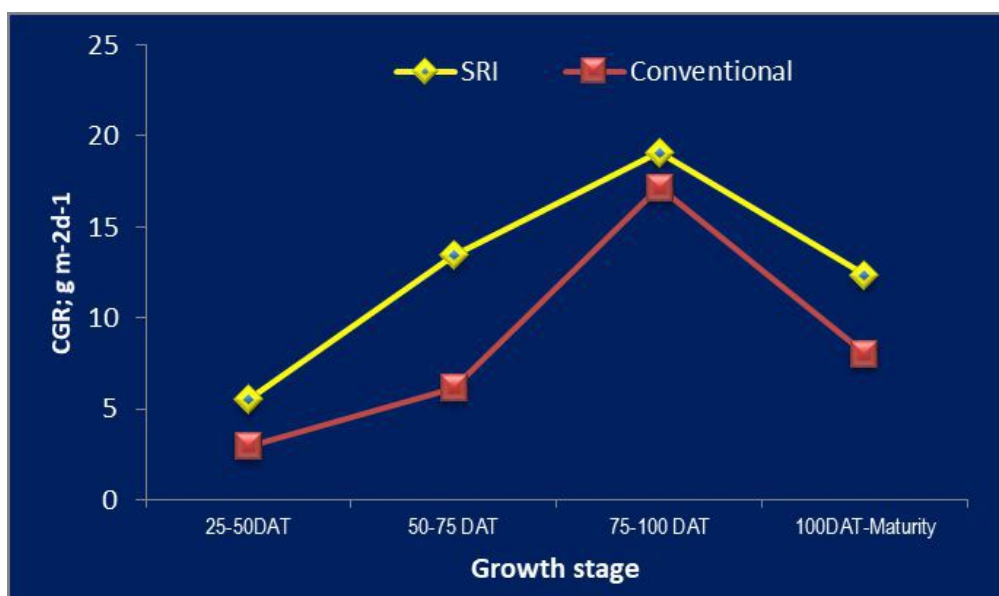


Fig 1: CGR as influenced by manipulation of microenvironment imposed by crop establishment (pooled data)

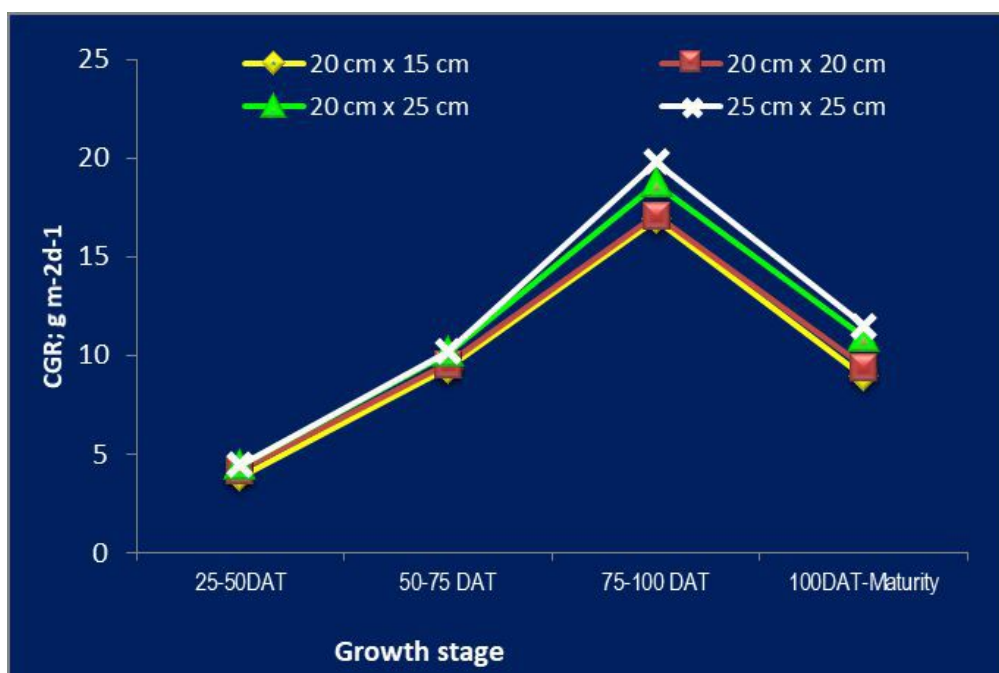


Fig 2: CGR as influenced by manipulation of microenvironment imposed by crop density (pool data)

Relative Growth Rate (RGR)

RGR exhibited a consistent declining trend with crop age, with the highest values observed during the early growth stage in both years (Fig.3 and 4), corroborating the findings of Alam *et al.* (2009) [1] and Sridevi and Chellamuthu (2015) [17]. The SRI method consistently outperformed the CRC system, showing significantly higher RGR during the early (25-50 DAT) and later (100 DAT to physiological maturity) stages across both years. No significant differences were noted between establishment methods during the mid-growth phases (50-75 DAT and 75-100 DAT), aligning with results reported by Sridevi and Chellamuthu (2015) [17].

Crop density showed a significant influence during the early (25-50 DAT) and late (100 DAT to PM) stages. The lowest density (25×25 cm; 16 hills m^{-2}) resulted in the highest RGR—33.97 $mg\ g^{-1}\ d^{-1}$ in 2016 and 31.68 $mg\ g^{-1}\ d^{-1}$ in 2017. Crop density of 25 hills m^{-2} produced comparable RGR values to the 16 hills m^{-2} treatment in both years. No significant differences in RGR were observed during the mid-growth stages. Similar positive effects of wider spacing on RGR have been reported by Vijayakumar *et al.* (2006) [20], and Rajput *et al.* (2017) [12].

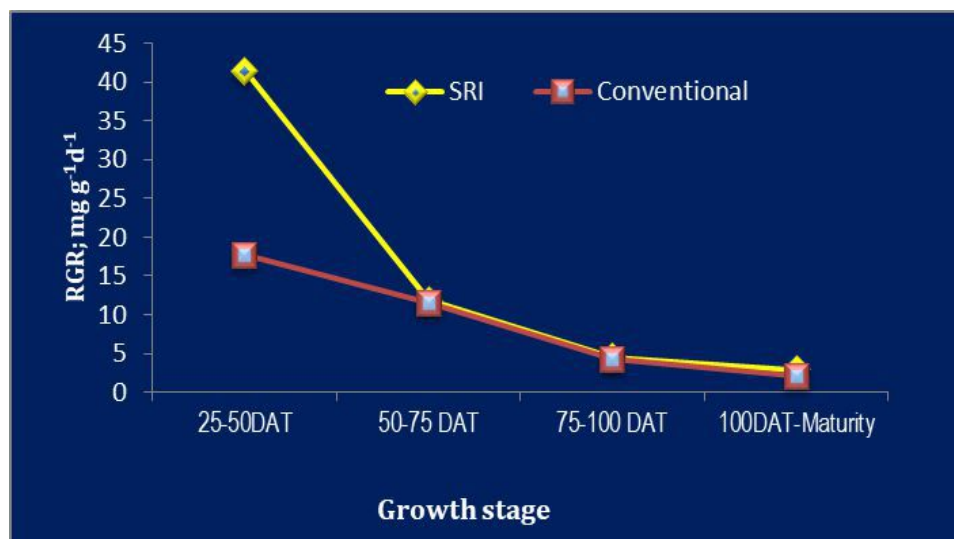


Fig 3: RGR as influenced by manipulation of microenvironment imposed by crop establishment (pooled data)

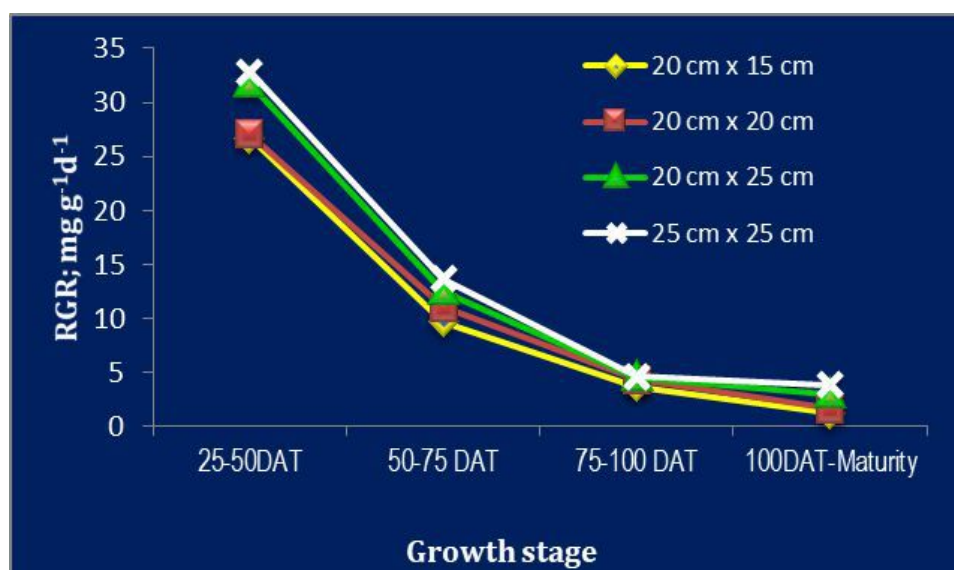


Fig 4: RGR as influenced by manipulation of microenvironment imposed by crop density (pooled data)

Net Assimilation Ratio (NAR): NAR was highest during the early growth phase (25-50 DAT) and declined progressively with crop age, reaching the lowest at harvest (Fig. 5-6). This decline is likely due to a reduction in the number of active leaves over time, resulting in decreased photosynthetic activity, as also reported by Haque and Haque (2016)[5]. The SRI recorded significantly higher NAR compared to the CRC during 25-50 DAT and 100 DAT to physiological maturity in both years. No significant differences between establishment methods were observed

during the mid-growth stages (50-100 DAT). The lower NAR under conventional practices may be attributed to reduced leaf productivity due to limited leaf area and suboptimal access to growth resources such as nutrients, space, and water. Crop density significantly influenced NAR at all stages except from 100 DAT to maturity. During 25-50 DAT, the lowest density of 16 hills m^{-2} (25×25 cm) consistently showed the highest NAR, followed in order by 20×25 cm, 20×20 cm, and 20×15 cm densities.

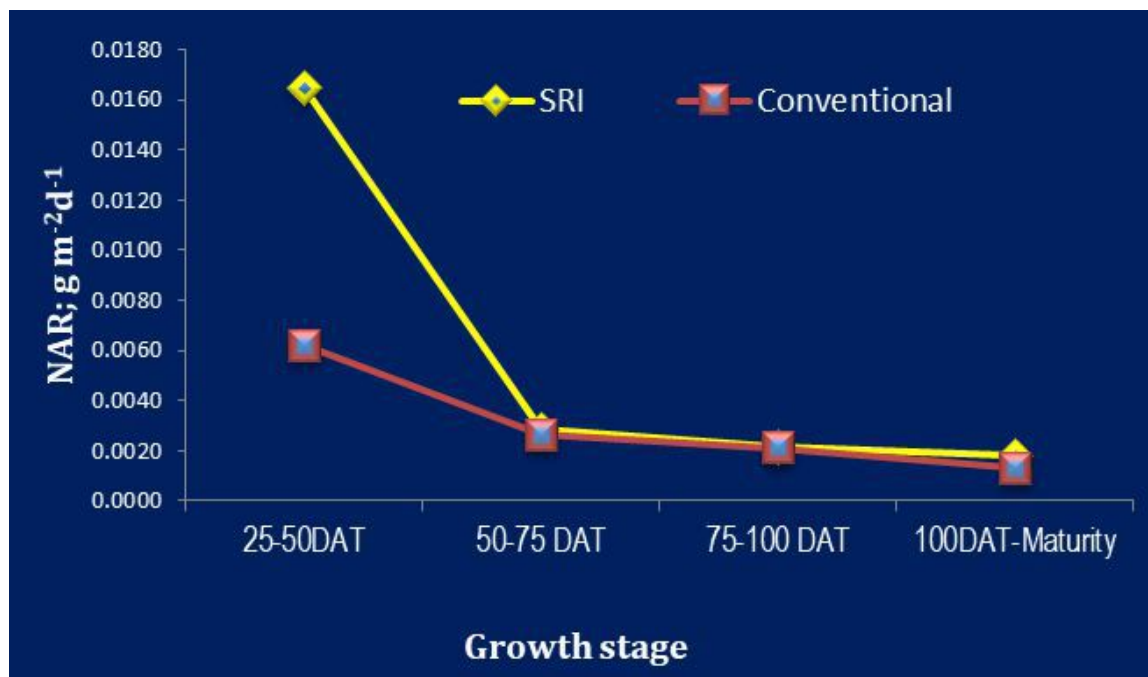


Fig 5: NAR as influenced by modification of microenvironments imposed by crop establishment (pooled data)

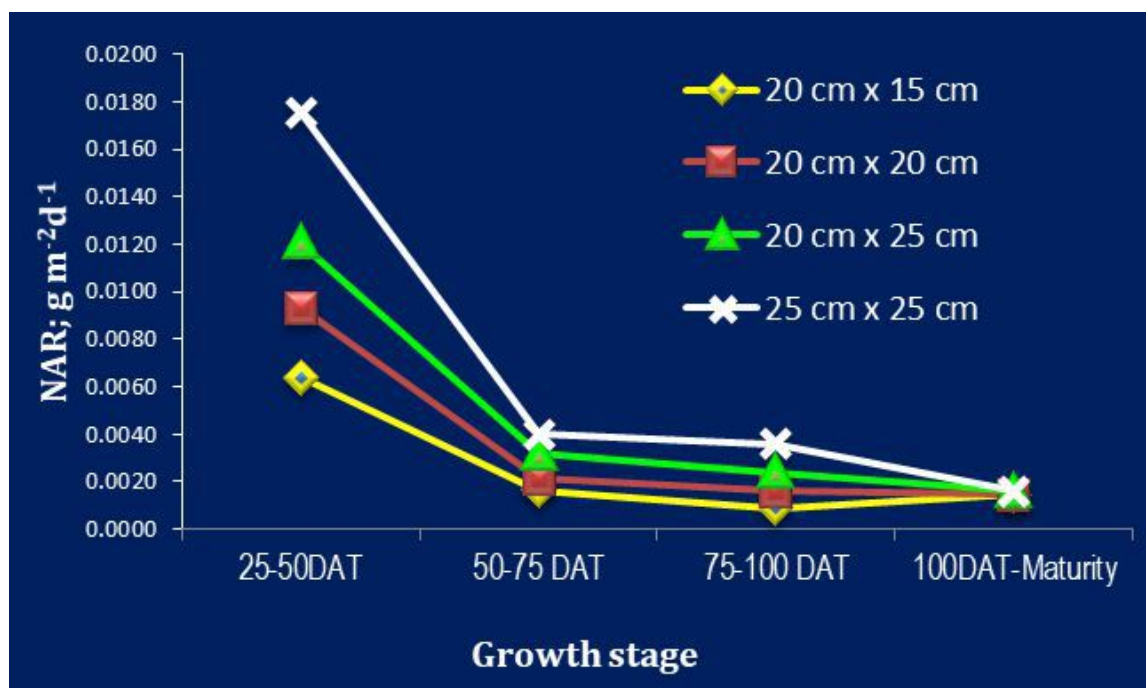


Fig 6: NAR as influenced by modification of microenvironments imposed by crop density (pooled data)

Leaf area index (LAI)

Leaf Area Index (LAI) was found to be increasing at an increasing rate, peaking at the flowering stage, followed by a sharp decline thereafter. Significantly higher LAI was observed under the SRI method from MTS to PM (Fig.7). However, during the tillering stage, LAI under SRI was notably lower than in the CRC system, likely due to the lag phase associated with the younger seedlings used in SRI. These findings align with the previous studies done by Thakur *et al.* (2010); Thakur *et al.* (2015) and Sridevi and Chellamuthu (2015) [17,18, 19].

The transplanting date had a significant effect on LAI (Fig.8). The 26th June planting resulted in the highest LAI,

with the 10th July transplanting showing statistically similar values. The lowest LAI was recorded with the 25th July planting. Crop density also influenced LAI throughout the crop growth period, except at the tillering stage, where no significant differences were observed (Fig.9). From MTS onward, the lowest density (16 hills m^{-2}) produced the highest LAI, significantly outperforming 25 and 33 hills m^{-2} , and was statistically comparable to 20 hills m^{-2} . These results are consistent with Shrirame *et al.* (2000) [16], who reported that wider spacing enhances photosynthetic efficiency through increased functional leaf area and number of tillers per hill.

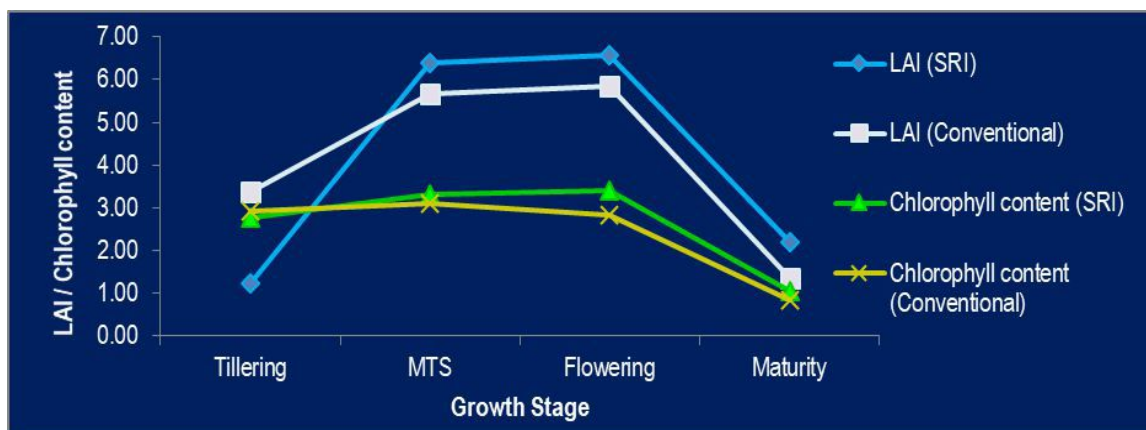


Fig 7: LAI and chlorophyll content (mg g⁻¹ fr. wt) as influenced by manipulation of microenvironment imposed by crop establishment (pooled data)

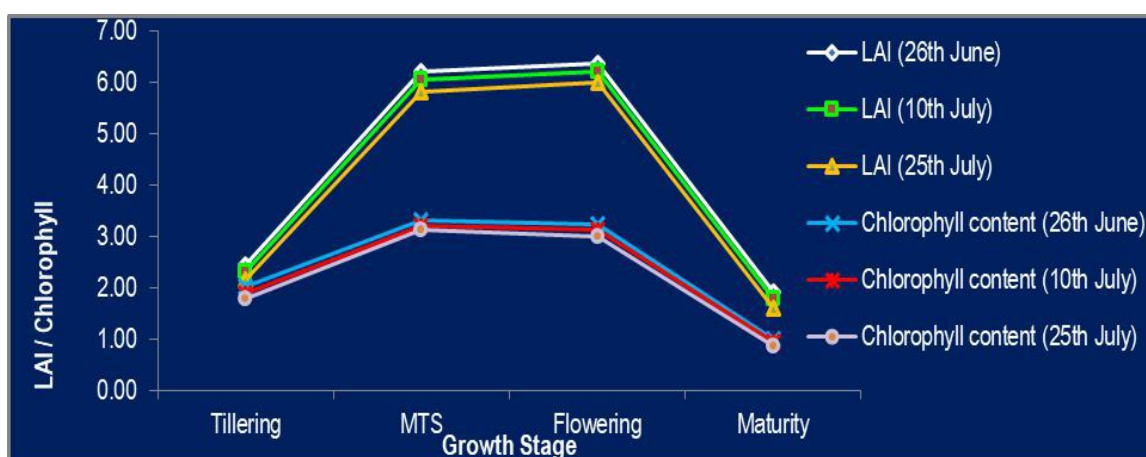


Fig 8: LAI and chlorophyll content (mg g⁻¹ fr. wt) as influenced by manipulation of microenvironment imposed by date of transplanting (pooled data)

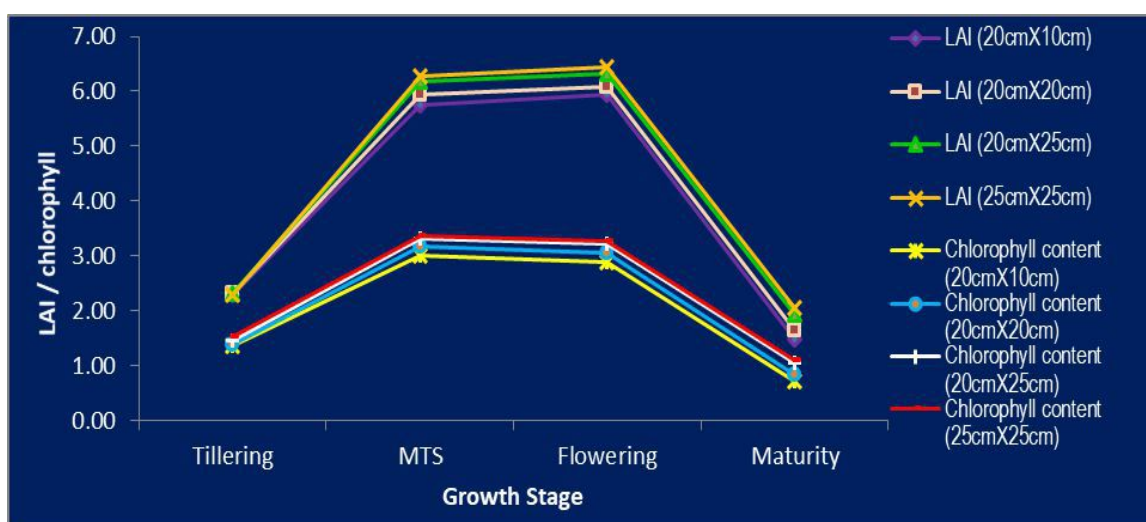


Fig 9: LAI and chlorophyll content (mg g⁻¹ fr. wt) as influenced by manipulation of microenvironment imposed by crop density (pooled data)

Chlorophyll Content

Throughout the crop growth period, SRI consistently recorded significantly higher chlorophyll content than the CRC system, except during the early stage (Fig. 7 to Fig. 9). Peak chlorophyll levels were observed at the flowering stage under SRI followed by a sharp decline towards maturity. The enhanced chlorophyll content under SRI might be due to its open canopy structure, which improves light interception and boosts physiological traits such as leaf area

and chlorophyll synthesis (Thakur *et al.*, 2010) [18]. Transplanting date also had a significant impact, with the 26th June planting consistently showing the highest chlorophyll content across all growth stages. In both years, chlorophyll levels increased steadily up to the maximum tillering stage, plateaued until flowering, and declined sharply thereafter in all planting dates. Chlorophyll content also increased with decreasing crop density. The highest values were recorded under the lowest density (16 hills m⁻²),

likely due to enhanced root-oxidizing activity in more widely spaced plants.

Conclusion

Two years of experiment showed a significant influence of crop microenvironment on the pattern of crop growth, which was depicted in terms of CGR, RGR and NAR. Crops grown under SRI system with a spacing of 25 cm × 25 cm showed higher magnitudes of RGR and NAR during the early growth stage, indicating boosted growth and physiological parameters. With higher LAI value, SRI establishment was found to be more active with significantly increased chlorophyll content, even up to flowering stage as compared to the conventional one. In brief, it was observed that the early transplanting of kharif paddy on 26th June with a crop density of 25 cm × 25 cm under the SRI method emerged as the most effective crop management strategy for enhancing growth and physiological parameters. This combination improved the key parameters by creating a favorable microenvironment for the kharif paddy of UBVZ of Assam under medium land situation.

Acknowledgement

The authors sincerely thank the Department of Agronomy, Assam Agricultural University (AAU), Jorhat, and KVK-Golaghat, AAU-Khumtai, for providing the essential facilities and support for both field and laboratory work. We are indebted to Mr. T. Saikia and Mr. D. Kaman for their unwavering dedication and hands-on involvement throughout the field research in the village.

References

1. Alam MM, Hasanuzzaman M, Nahar K. Growth pattern of three high-yielding rice varieties under different phosphorus levels. *Advances in Biological Research*. 2009;3(3-4):110-116.
2. Chakraborty S, Biswas PK, Roy TS, Mahmud A, Mehraj H, Uddin J. Growth and yield of Boro rice (BRRI Dhan 50) as affected by planting geometry under system of rice intensification. *Journal of Bioscience and Agriculture Research*. 2014;2(1):36-43.
3. Chen X, Cui Z, Fan M, Vitousek P, Zhao M, Ma W, *et al*. Producing more grain with lower environmental costs. *Nature*. 2014;514(7523):486-489.
4. Gautam P, Lal B, Nayak AK, Raja R, Panda BB, Tripathi R, *et al*. Inter-relationship between intercepted radiation and rice yield influenced by transplanting time, method, and variety. *International Journal of Biometeorology*. 2019;63(3):337-349.
5. Haque MA, Haque MM. Growth, yield and nitrogen use efficiency of new rice variety under variable nitrogen rates. *American Journal of Plant Sciences*. 2016;7(3):612-622.
6. Hosain T, Hossain E, Nizam R, Fazle Bari ASM, Chakraborty R. Response of physiological characteristics and productivity of hybrid rice varieties under system of rice intensification (SRI) over the traditional cultivation. *International Journal of Plant Biology Research*. 2018;6(2):1085.
7. Jayapriya S, Ravichandran V, Boominathan P. Influence of sowing windows on phenology, growing degree days and yield traits of rice genotypes. *Madras Agricultural Journal*. 2016;103:1-6.
8. Kalita R, Thakuria RK, Medhi BK, Saikia M. Production maximization of rainy season rice (*Oryza sativa* L.) through effective use of water and solar radiation under modified system of rice intensification in Assam. *Indian Journal of Agronomy*. 2023;68(1):1-8.
9. Kalita R, Thakuria R, Medhi B, Borkotoky B, Changmai R. Influence of microclimate on crop growth, soil respiration and carbon sequestration under varied agronomic management in Sali paddy in Assam. *International Journal of Research in Agronomy*. 2024;7(7):738-744.
10. Kalita R, Thakuria R, Medhi B, Saikia M, Baruah PJ, Changmai R, *et al*. Agronomic manipulation on nutrient uptake and status in Sali rice under varied crop establishment in the inceptisol of Assam. *International Journal of Advanced Biochemistry Research*. 2025;9(3):312-316.
11. Mohanty TR, Maity SK, Roul PK, Sahoo KC. Studies on yield, economics and energetics of rice (*Oryza sativa* L.) in relation to crop establishment methods and nutrient management practices. *International Journal of Bio-resource and Stress Management*. 2014;5(4):495.
12. Rajput A, Rajput SS, Jha G. Physiological parameters leaf area index, crop growth rate, relative growth rate and net assimilation rate of different varieties of rice grown under different planting geometries and depths in SRI. *International Journal of Pure & Applied Bioscience*. 2017;5(1):362-367.
13. Shantappa D, Tirupataiah K, Yella Reddy K, Sandhyarani K, Mahendra Kumar R, Kadasiddappa M. Yield and water productivity of rice under different cultivation practices and irrigation regimes. *International Symposium on Integrated Water Resources Management (IWRM-2014)*. 2014;19-21 February:938-943.
14. Sharma A, Dhaliwal LK, Sandhu SK, Singh SP. Effect of plant spacing and transplanting time on phenology, tiller production and yield of rice (*Oryza sativa* L.). *International Journal of Agricultural Sciences*. 2011;7(2):249-253.
15. Sharma N, Murty NS, Mall P, Bhardwaj SB. An analysis on the yield and yield contributing characters of rice in Tarai region of Uttarakhand. *International Journal of Chemical Studies*. 2018;6(3):42-47.
16. Shrirame MD, Rajgire HJ, Rajgire AH. Effect of spacing and seedling number per hill on growth attributes and yield of rice hybrids under lowland condition. *Journal of Soils and Crops*. 2000;10(1):109-113.
17. Sridevi V, Chellamuthu V. Growth analysis and yield of rice as affected by different system of rice intensification (SRI) practices. *International Journal of Research in Applied, Natural and Social Science*. 2015;3:29-36.
18. Thakur AK. Critiquing SRI criticism: Beyond scepticism with empiricism. *Current Science*. 2010;98(10):1294-1299.
19. Thakur AK, Mohanty RK, Singh R, Patil DU. Enhancing water and cropping productivity through Integrated System of Rice Intensification (ISRI) with aquaculture and horticulture under rainfed conditions. *Agricultural Water Management*. 2015;161:65-76.
20. Vijayakumar M, Ramesh S, Prabhakaran NK, Subbian P, Chandrasekaran B. Influence of system of rice intensification (SRI) practices on growth characters, days to flowering, growth analysis and labour productivity of rice. *Asian Journal of Plant Sciences*. 2006;5(6):984-989.