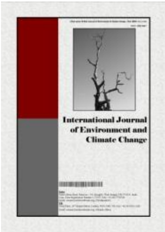

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Effect of Low Light Stress on Plant Height, Tiller Number, Panicle Number, Leaf Area and Yield of Long Duration Rice (*Oryza sativa. L*) Varieties

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The purpose of this study was to determine the impact of low light stress on the morphological parameters and yield of long duration rice genotypes. The experiment was carried out in the field of National Rice Research Institute, and the field layout was done as per the split plot design, with the light in the main plot and the varieties in the sub-plot. During *Kharif* 2019, the experiment was carried out at plot-4, V-block under the Department of Crop Physiology and Biochemistry at the National Rice Research Institute (NRRI), Cuttack. The experiment was carried out with three different light intensities, namely 100% light as treatment-I (Control), 75% light as treatment-II, and 50% light as treatment-III. Eleven long duration rice varieties were chosen based on yield to

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investigate the effect of low light on their morphology and yield. It was observed that at 50% flowering stage in 75% and 50% light intensities, plant height and leaf area increases but tiller number, panicle number and yield reduces. At 50% light intensity, yield reduction was significantly greater than 75% light intensity. Among the varieties Nasati Sali, Nalini Sali and Swarnaprabha was recorded highest grain yield in 100% (5.10 t ha^{-1}), 75% (4.27 t ha^{-1}) and 50% light intensity (3.05 t ha^{-1}) respectively.

Keywords: Low light intensity; plant height; tiller number; panicle number; leaf area; grain yield.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the world's second most important cereal crop, belonging to the Gramineae family and providing primary food for approximately 65 percent of the world's population. Rice contributes 75 percent of calories and 55 percent of proteins to the average daily diet of consumers [1], and it also helps to enrich the nation's economy. For the year 2020-21, total food grain production was 305.44 million tonnes, with 121.46 million tonnes of rice produced from 44 million hectors in India (Ministry of Agriculture & Farmers Welfare-2021). Light plays an important role in rice plant growth and development [2]. Even though each plant has its own natural growth cycle, the vegetative and reproductive stages of growth are directly governed by light due to its critical role in photosynthesis and photomorphogenesis. Germination, seasonal and diurnal time sensing, plant stature, growth habits, and the transition to flowering and fruit ripening are all influenced by lighting parameters [3]. Controlling the quantity (intensity and duration) and quality (colour, wave length) of light reaching the plants is therefore critical. Each plant species required a specific amount of light intensity for a specific duration in order to ensure effective growth, sustained development, and maximised crop productivity [4]. A deviation from the optimal light requirement may stress the plant. Low light stress occurs when the amount of light intensity that reaches the plants is less than the optimum level. Climate change results in overcast cloud throughout the growing season, *Kharif* season rice crops in India and South Asia receive less irradiation [5]. The major rice growing areas in India's eastern and north eastern states are mostly affected by low irradiance because they receive only about 800-900 BSS hours from August to December, as opposed to 1500 BSS hours from transplanting to maturity. This reduces physiological efficiencies and, as a result, the productivity of the winter rice crop [6]. Keeping in mind the above issues the present experiment was designed to know the impact of low light stress on rice morphology at 50% flowering stage and its effect on grain yield.

1.1 Experimental Methods

During the *Kharif* (wet) season of 2019-20, the field experiment was carried out in the research plot No.4, V-block of the Division of Crop Physiology and Biochemistry National Rice Research Institute, Cuttack, India (85°55'48"E–85°56'48"E and 20°26'35"N–20°27'20"N).

After 30 days of sowing, when the seedlings have reached a height of 12-15 cm and are ready for transplanting, the field was fine-tilted with criss-cross tractors, followed by ploughing and harrowing. The field was then puddled

Table 1. Details of field design and layout

Experimental design	Split plot
Number of treatments(main plot)	3
L1	Control (100% light intensity i.e. Normal light)
L2	Low light treatment (75% of normal light intensity)
L3	Low light treatment (50% of normal light intensity)
Number of genotypes (sub plot)	50
Number of replications	3
No. of rows for each genotype	3
No. of plants in each row	15
Length of each row	3 m
Plant spacing	20 cm X 15 cm

Fig. 1. Experimental field view

with a tractor before being levelled. The field is thoroughly watered the day before transplanting, and a bund is properly constructed to divide the field into three different treatments, as planned. After 30 days of transplanting, a 75 percent light and 50 percent light penetrating shade-net was installed in two treatments on a wooden bamboo frame to create low light stress. The control plot was set to 100% light intensity (normal light). Observations on plant height, tiller number, panicle number, and leaf area were made with three replications at 50% flowering.

Plant height: The perpendicular distances from the base to the tip of the longest leaf of five plants were measured with help of a wooden scale. A similar procedure was followed for all three replications. The average height was calculated and expressed in centimetres.

Tiller number: The number of tillers per 5 hills was counted for each of three replications and the average was calculated during 50% flowering.

Panicles number: The number of panicles per 5 hills was counted for each of the three replications and the average was calculated during 50% flowering.

Leaf Area: The uppermost fully expanded leaf of the mother tiller was selected for the estimation leaf area at 50% flowering stage. Leaf area of 10 leaves of each variety under all three replication of each treatment was measured with help of leaf area meter and expressed in cm^2.

2. RESULTS AND DISCUSSION

2.1 Effect of Low Light Intensities on Plant Height at 50% Flowering

Effect of low light stress on plant height during flowering stage among selected rice genotypes is represents in Tables 2 and 3 .The present study describes a significant change in plant height in low light stress. Among the three light intensities, plants grown under 50% light intensities recorded significantly higher plant height (162.40 cm) followed by 75% light intensity (151.24 cm) and 100% light intensity (141.45 cm). Similar result were obtained by singh, 1988 and as per him low light has a prominent effect of increased plant height due to stimulation of expansins causing and rapid cell division along with elongation. Among the genotypes highest plant height was observed in Na Sali (184.11 cm) and least plant height was observed in IR-8 (103.09). The interaction effect of light and genotypes are significant with respect to height of the plants. It shows that Na Sali in 75% light intensity (192.03 cm) having the highest plant height among all the interactions but IR-8 at 100% light intensity (86.98) having the lowest plant height among all the interactions and it was concluded that irrespective of varieties the low light intensity decreases the plant height significantly. The result is also supported by Ren et al., [7]. According to them that low light results in increased plant height and increased Specific leaf Area (SLA) under low light stress. condition plants grown under shading condition shown a higher internode length that's the reason increased height is a feature of plants under shade [8].

Table 2. Effect of low light stress on plant height (cm), tillernumber, panicle number and leaf area (cm^2) of rice genotypes at 50% flowering stage during khatif 2019-20

Light Intensity	Plant Height (cm)	Tiller number m^{-2}	Panicle number m^{-2}	Leaf area (cm^2/ leaf)
L1 (100% L)	141.45	220.99	185.20	43.57
L2(75%L)	151.24	209.49	149.20	53.04
L3 (50%L)	162.40	192.33	119.60	57.30
SE(m)±	0.80	6.93	5.35	0.78
CD(0.05)	2.21	19.24	14.87	2.17
Genotype				
Swarnaprabha	138.17	255.30	196.53	59.18
IR-8	103.09	202.76	147.40	39.05
Nalini Sali	149.40	216.82	189.93	59.60
Sagara Sali	162.29	207.94	115.87	42.15
Getw Sali	166.81	175.38	140.80	48.01
Sali Bahan	173.53	202.76	138.60	50.85
Kola Bordhan	151.21	179.82	133.47	45.58
Moimonsingia	115.80	239.02	157.67	45.33
Na Sali	184.11	209.42	149.60	56.41
Nasati Sali	176.93	202.02	140.07	65.55
Torabali	147.29	192.40	154.73	52.61
SE(m)±	1.62	13.00	12.20	1.12
CD(0.05)	3.24	26.00	24.41	2.23

Table 3. Interaction effect of light and varieties on plant height (cm) at 50% flowering stage during *Kharif* 2019-20

Plant Height (cm)	100% Light	75% Light	50% Light
Swarnaprabha	132.56	138.02	143.94
IR-8	86.98	100.74	121.56
Nalini Sali	136.33	145.00	166.87
Sagara Sali	144.53	164.72	177.62
Getw Sali	161.78	166.53	172.11
Sali Bahan	159.67	172.50	188.42
Kola Bordhan	144.87	149.89	158.89
Moimonsingia	109.83	115.78	121.80
Na Sali	172.37	192.03	187.94
Nasati Sali	168.00	177.50	185.28
Torabali	138.99	140.94	161.92
	L in G	G in L	
SE(m)±	2.79	2.80	
CD(0.05)	5.58	5.61	

2.2 Effect of Low Light Intensities on Tiller Number at 50% Flowering

Total number of tillers m^{-2} Showing an opposite trend to plant height and represented in Table 2. In the present study the light intensity is directly proportional to number of tiller production during 50% flowering stage. Therefore among the three light conditions, highest number of tillers was recorded in 100% light intensity (220.99). It is reported that low light during flowering and harvesting stage is most detrimental to tiller production resulting in fewer panicle production and total biomass [9]. Among the genotypes, swarnaprabha was recorded highest tiller number (255.30) and Getw Sali (175.38) was recorded lowest number of tillers m^{-2} at 50% flowering stage. The low light intensity treatments carried out from the early vegetative growth stage until harvesting time significantly reduced the number of productive tillers and panicles in rice plants [10].

2.3 Effect of Low Light Intensities on Panicle Number at 50% Flowering

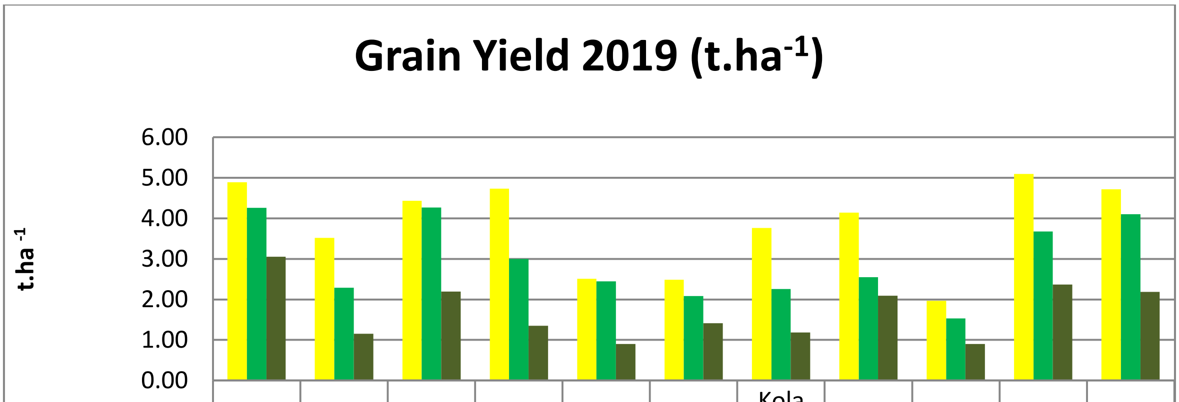
Panicle number at 50% flowering stage was recorded and noted in Table 2. Number of panicle decreases along with the reduction of light intensity therefore in the present study plants grown under 50% light intensity recorded lowest number of panicles (119.60) and in contrast to that plants grown under 100% light intensity shows highest number of panicles m^{-2}. Similar result was also reported by Ren et al., [10]. As per them as the productive tillers are reduced under low light intensity it results in reduced panicle number. Among the genotypes Swarnaprabha (196.53) and Sagara Sali (115.87) recorded highest and lowest number of panicles respectively at 50% flowering stage. The light and genotype interaction was non-significant with respect to panicle number.

2.4 Effect of Low Light Intensities on Leaf Area at 50% Flowering

Leaf area increases under low light intensities in all the genotypes and presented in Tables 2 and 4. Plants under 50% light intensity recorded highest leaf area (57.30 cm. $leaf^{-1}$) followed by 75% and 100% light intensity. Similar results were obtained by Sibing et al. (2004). They observed a 5.76% and 29.83% increase in leaf area under 50% and 20% light condition respectively. The more expanation of leaf under low light is may be for increasing the light exposer under low light stress. Among the genotypes Nasati Sali having highest leaf area (65.55 cm. $leaf^{-1}$) followed by Nalinisali and Swarnaprabha. The interaction effect of light and genotypes against leaf area is significantly high for Nasati Sali (69.86 cm. $leaf^{-1}$).

2.5 Effect of Low Light Intensities on Grain Yield during *Kharif* 2019-20

Effect of light and genotypes on grain yield was recorded and presented in Fig. 2. Among the genotypes highest yield was obtained from Nasati Sali (5.10 $t.ha^{-1}$) in 100% light intensity. As the light intensity decreases the yield reduction in this genotypes also increases as the grain yield decreases. At 75% light intensity Nalini Sali and Swarnaprabha maintained their yield and recorded 4.27 and 4.26 $t.ha^{-1}$ grain yield but at 50% light intensity the yield of every variety reduced drastically and highest yield was observed in Swarnaprabha. Similar result was also observed by Thuy and Saitoh, (2017) with 32.2-65 % yield reduction in shaded condition. According to them major cause of yield reuction in low light is due to spikelet sterility. Similarly Dutta et al., [11] reported that grain yield, plant height and pollen viability are the major constituents, contributing 63.95 % for principal component analysis under low light condition [12].



	Swarna prabha	IR-8	Nalini Sali	Sagara Sali	Getw Sali	Sali Bahan	Kola Bordha n	Moimo nsingia	Na Sali	Nasati Sali	Toraba li
Normal Light	4.89	3.52	4.44	4.74	2.51	2.49	3.77	4.14	1.96	5.10	4.72
75%Light	4.26	2.29	4.27	3.00	2.44	2.09	2.25	2.55	1.53	3.68	4.10
50% Light	3.05	1.16	2.19	1.35	0.90	1.41	1.19	2.09	0.90	2.37	2.18

Fig. 2. Effect of low light intensities and genotypes on grain yield during kharif 2019-20

Table 4. Interaction effect of light and varieties on leaf area at 50% flowering stage during *Kharif* 2019-20

Leaf area (cm^2)	100% Light	75%Light	50% Light
Swarnaprabha	42.11	67.67	67.77
IR-8	34.25	39.71	43.20
Nalini Sali	57.07	58.57	63.16
Sagara Sali	37.44	42.03	46.99
Getw Sali	46.46	48.28	49.30
Sali Bahan	42.61	54.16	55.77
Kola Bordhan	36.68	47.39	52.68
Moimonsingia	33.96	42.97	59.07
Na Sali	47.39	58.11	63.71
Nasati Sali	58.67	68.11	69.86
Torabali	42.63	56.46	58.74
	L in G	G in L	
SE(m)±	2.00	1.93	
CD(0.05)	4.01	3.87	

3. CONCLUSION

The above study concludes that plant height and leaf area shows a increasing trend under low light stress and in contrast to it tiller number, panicle number and grain yield reduced under low light stress and among the varieties Swarnaprabha, Nasati Sali and Nalini Sali showed a less reduction yield in low light intensities comparison to other genotypes therefore may be considered for higher low light tolerant.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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