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Impact of low light stress on morphological and growth behavior of early, medium and late rice genotypes (*Oryza Sativa* L.)

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Abstract

This study investigates the effect of normal and low light conditions on the anthesis, flowering, maturity, and growth parameters of different rice genotypes (*Oryza sativa* L.). The results demonstrate that low light intensity delays flowering initiation and extends the duration to 50% and 100% flowering, with variations across early, medium, and late genotypes. The time to maturity also increases under low light conditions, while plant height, number of leaves, and tillers per hill show significant changes. Specifically, low light stress enhances plant height but reduces leaf and tiller numbers, likely due to impaired photosynthesis. These findings are consistent with previous research indicating that low light negatively impacts growth and development by limiting energy production for vegetative and reproductive processes.

Keywords: Normal light (NI), low light (LL), anthesis, flowering

Introduction

Rice is a kind of grass called *Oryza glaberrima* (also known as African rice) or *Oryza sativa* (Asian rice). Light has long been known to be the most important factor influencing plant growth with changes in irradiance having impacts on plant growth, morphology, anatomy various aspect of Morphology and ultimately flowering time. Although light is a crucial factor for plant growth but excess light is not utilized in photosynthesis can produce chronic photo-inhibition. Leaf metabolism is severely inhibited and light induced damage to photosystem II is more likely to occur when plants were exposed to stress (Dai *et al.*, 2009) [1].

Methods and Materials

A field research trial was carried out at the Research cum Instructional Farm during the *Kharif* season of 2022-2023. Laboratory analyses were conducted in the Department of Plant Physiology at the College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Krishak Nagar, Raipur (C.G.). The experimental materials, consisting of 14 genotypes, were obtained from DRR, Hyderabad, along with a check variety from IGKV, Raipur, for the *Kharif* 2022-23 season. The genotypes were classified into early, medium, and late categories.

Treatments details

T₁: Control (Normal light).
 T₂: Low light (Net shade 70:30).

Results and Discussion

Effect of light intervention on morphological and growth behavior of rice genotypes. Effect of normal light and low light on anthesis of rice (*Oryza sativa* L.) genotypes.

The effects of normal and low light on days of first flowering initiation of different rice genotypes are presented in Table 1. The period for days of first flowering initiation was observed in early genotypes 48 to 70, medium genotypes 70.67 to 79.33 and late genotypes 77.67 to 96.67 respectively.

However, the duration extended in early genotypes range from 52.67 to 72.67, medium genotypes 77 to 83.33 and late genotypes 81.33 to 102.33 days to anthesis under low light condition.

Flower initiation was observed to be delayed under low light intensities, which correlated with diminished growth rates in terms of dry weight, decreased rates of leaf initiation and an increased number of leaves formed below the flower. A comparable finding was previously reported by Orzek *et al.* (2009) [4].

Effect of normal light and low light on days of 50% flowering of rice (*Oryza sativa* L.) genotype

The data recorded for the duration of 50% flowering display in Table 2 and noticeable variations were observed among the treatments. The significant variations were observed in terms of flowering time under normal light and low light stress conditions. In normal light condition, the time span for 50% flowering ranged from 55.67 to 75.67 days for early genotypes, 75.33 to 85.67 days for medium genotypes and 85.33 to 101.67 days for late genotypes. However, the range extended from 62.33 to 81.33 days for early genotypes, 81.67 to 90.00 days for medium genotypes and 90.33 to 106.33 days for late genotypes under low light condition.

The examined genotypes, including the check variety, exhibited slight variations in the number of days required for flowering and statistical analysis confirmed the significance of the data. These outcomes align with the observations made by Orzek *et al.* (2009) [4], who reported that flower initiation is delayed under low light intensities. This delay was attributed to decreased rates of growth in terms of dry weight, reduced leaf initiation rates and an increased number of leaves formed below the flower.

Effect of normal light and low light on days of 100% flowering of rice (*Oryza sativa* L.) genotypes

The effects of normal light and low light on days of 100% flowering of rice genotypes presented in Table 4.3. The flowering time of rice plants exhibited significant variations in response to different light conditions. Under normal lighting, early genotypes took 61.67 to 82.67 days, medium genotypes required 82.67 to 90.67 days and late genotypes required 90.67 to 106.67 days for 100% flowering. Conversely, low lighting condition resulted in an extended flowering time with early genotypes flowering was 66.67 to 89.33 days, medium genotypes 89.33 to 96.33 days and late genotypes range was 96.33 to 112.33 days. Similar result was also reported by Orzek *et al.* (2009) [4].

Effect of normal light and low light on days to maturity of rice (*Oryza sativa* L.) genotypes

The information regarding the number of days until maturity shown in Table 4.4 and it indicates significant variations among the treatments concerned with maturity stage. The significant variations were observed on days to maturity of tested rice genotypes under both normal light and low light stress condition. In normal light condition, early genotypes required 88.67 to 103.33 days to reach maturity, medium genotypes took 110.33 to 115.67 days, and late genotypes 112.33 to 134.67 days to maturity. Conversely, when exposed to low light condition, the maturity period was prolonged with early genotypes took 93 to 110.67 days, medium genotypes 116.33 to 118.67 days and late genotypes requiring 96.33 to 112.33 days to reach maturity.

The rice genotypes demonstrated a shorter duration for anthesis, 50% flowering and maturity under low light condition. The maturity of the plants was delayed with decreasing light intensity, which aligns with the findings of Orzek *et al.* (2009) [4].

Effect of normal light and low light on plant height (cm) at flowering stage of rice (*Oryza sativa* L.) genotypes

The recorded measurement of plant height was depicted in Table 4.5 and the variation was observed among the treatments at flowering stage. The plant height of rice genotypes were found significant differences during the flowering stage when comparing with normal light conditions to low light stress condition. In normal light, plant height was recorded in early duration genotypes range from 104.90 to 157.73 cm, medium duration genotypes ranged from 95.87 to 104.27 cm and late duration genotypes varied between 105.33 and 137.70 cm. Conversely, early duration genotypes displayed an extended plant height range from 113.67 to 172.67 cm, medium duration genotypes ranged from 105.53 to 112.60 cm and late duration genotypes ranged from 110.20 to 112.43 cm under low light condition.

These results indicated a significant increase in plant height for all genotypes under low light stress. The previous studies by Singh *et al.* (1988) [7] concluded that plant height expands under low light intensity, as the shade stimulates cellular expansion and rapid cell division. Gbadamosi *et al.* (2014) [2] also found significant differences in plant height with increasing light intensity, supporting these findings. Similarly, results were reported by Ren *et al.* (2002) [6].

Effect of normal light and low light on number of leaves per hill at flowering stage of rice (*Oryza sativa* L.) genotypes

The number of leaves is displayed in Table 4.6 which revealing significant difference among the treatments in terms of number of leaves. The significant variation in leaf count per hill was observed during the flowering stage under both normal and low light stress conditions. In normal light, early genotypes possessed an average of 83.03 to 93.88 leaves per hill, medium genotypes had an average of 84.18 to 92.03 leaves per hill and late genotypes possessed an average of 70.37 to 92.03 leaves per hill. However, the number of leaves per hill for early genotypes ranged from 45.21 to 74.16, medium genotypes ranged from 63.89 to 74.16 leaves per hill and late genotypes ranged from 51.39 to 89.10 leaves per hill flowering stage under low light condition.

Effects of normal light and low light on number of tillers per hill at flowering stage of rice (*Oryza sativa* L.) genotypes

The data regarding the number of tillers per plant revealed in Table 4.7 at flowering stage. The number of tillers per hill was significantly difference under low light and normal light condition. Under normal light, the early genotypes the range was 16.22 to 22.01 tillers per hill, the medium genotypes showed range from 14.60 to 20.54 tillers per hill and the late genotypes demonstrated a range of 12.60 to 20.45 tillers per hill at flowering stage. However, when subjected to low light condition, the early genotypes displayed a variation from 9.62 to 15.90 tillers per hill, the medium genotypes exhibited a variation of 13.14 to 17.29 tillers per hill and the

late genotypes was observed variation from 10.58 to 18.76 tillers per hill at flowering stage.

Insufficient light intensity leads to a reduction in the number of tillers by impeding photosynthesis. In conditions of low light, the source organs are unable to produce sufficient assimilates to fulfill the demands for tiller emergence. The tillering capacity and productivity of rice are influenced by

shading during the early stages leading to a decrease in the number of tillers as light intensity reduced. Xiu *et al.* (2013)^[8] established that insufficient light stress adversely impacts various aspects of vegetative growth, including tiller count, rice yield and quality. These findings align with the observations made by Singh *et al.* (1988)^[7] and Liu *et al.* (2009)^[5].

Table 1: Effect of normal light (NL) and low light (LL) on anthesis of rice (*Oryza sativa* L.) genotypes

| | Genotype | Control (NL) | Treated (LL) | Varietal Mean |
|--------|----------------|--------------|--------------|---------------|
| Early | LL-604 | 64.67 | 67.67 | 66.17 |
| | LL-609 | 70.00 | 72.67 | 71.33 |
| | Poornima | 48.00 | 52.67 | 50.33 |
| Medium | LL-612 | 79.33 | 83.33 | 81.33 |
| | LL-613 | 76.33 | 79.67 | 78.00 |
| | LL-614 | 70.67 | 77.00 | 73.83 |
| Late | LL-601 | 77.67 | 81.33 | 79.50 |
| | LL-602 | 78.67 | 83.00 | 80.83 |
| | LL-603 | 86.67 | 91.00 | 88.83 |
| | LL-605 | 79.67 | 85.33 | 82.50 |
| | LL-606 | 79.33 | 86.67 | 83.00 |
| | LL-607 | 86.00 | 91.67 | 88.83 |
| | LL-608 | 95.67 | 102.33 | 99.00 |
| | LL-610 | 90.33 | 95.67 | 93.00 |
| | LL-611 | 96.67 | 102.33 | 99.50 |
| | Treatment Mean | 78.64 | 83.49 | |

ANOVA Table

| Factors | C.D. | SE(d) | SE(m) |
|----------------|-------|-------|-------|
| Factor(A) | 0.284 | 0.142 | 0.1 |
| Factor(B) | 0.778 | 0.388 | 0.274 |
| Factor (A X B) | 1.1 | 0.548 | 0.388 |

Table 2: Effect of normal light (NL) and low light (LL) on days of 50% flowering of rice (*Oryza sativa* L.) genotypes

| | Genotype | Control (NL) | Treated (LL) | Varietal Mean |
|--------|----------------|--------------|--------------|---------------|
| Early | LL-604 | 69.67 | 75.67 | 72.67 |
| | LL-609 | 75.67 | 81.33 | 78.50 |
| | Poornima | 55.67 | 62.33 | 59.00 |
| Medium | LL-612 | 85.67 | 90.00 | 87.83 |
| | LL-613 | 79.67 | 84.67 | 82.17 |
| | LL-614 | 75.33 | 81.67 | 78.50 |
| Late | LL-601 | 87.67 | 92.67 | 90.17 |
| | LL-602 | 85.33 | 90.33 | 87.83 |
| | LL-603 | 90.67 | 95.67 | 93.17 |
| | LL-605 | 85.67 | 91.00 | 88.33 |
| | LL-606 | 90.67 | 95.67 | 93.17 |
| | LL-607 | 93.33 | 98.67 | 96.00 |
| | LL-608 | 101.67 | 106.33 | 104.00 |
| | LL-610 | 96.33 | 102.33 | 99.33 |
| | LL-611 | 101.33 | 105.33 | 103.33 |
| | Treatment Mean | 84.96 | 90.24 | |

ANOVA Table

| Factors | C.D. | SE(d) | SE(m) |
|----------------|-------|-------|-------|
| Factor (A) | 0.277 | 0.138 | 0.098 |
| Factor (B) | 0.759 | 0.378 | 0.267 |
| Factor (A X B) | 1.073 | 0.535 | 0.378 |

Table 3: Effect of normal light (NL) and low light (LL) on days of 100% flowering of rice (*Oryza sativa* L.) genotypes

| | Genotype | Control (NL) | Treated (LL) | Varietal Mean |
|--------|----------------|--------------|--------------|---------------|
| Early | LL-604 | 79.67 | 85.33 | 82.50 |
| | LL-609 | 82.67 | 89.33 | 86.00 |
| | Poornima | 61.67 | 66.67 | 64.17 |
| Medium | LL-612 | 90.67 | 96.33 | 93.50 |
| | LL-613 | 90.67 | 95.33 | 93.00 |
| | LL-614 | 82.67 | 89.33 | 86.00 |
| Late | LL-601 | 93.67 | 98.33 | 96.00 |
| | LL-602 | 90.67 | 96.33 | 93.50 |
| | LL-603 | 96.67 | 102.33 | 99.50 |
| | LL-605 | 90.67 | 96.33 | 93.50 |
| | LL-606 | 96.67 | 102.33 | 99.50 |
| | LL-607 | 106.67 | 111.33 | 109.00 |
| | LL-608 | 106.67 | 112.33 | 109.50 |
| | LL-610 | 103.67 | 109.33 | 106.50 |
| | LL-611 | 106.67 | 111.67 | 109.17 |
| | Treatment Mean | 92.00 | 97.51 | |

ANOVA Table

| Factors | C.D. | SE(d) | SE(m) |
|---------------|-------|-------|-------|
| Factor(A) | 0.233 | 0.116 | 0.082 |
| Factor(B) | 0.638 | 0.318 | 0.225 |
| Factor(A X B) | 0.902 | 0.449 | 0.318 |

Table 4: Effect of normal light (NL) and low light (LL) on days of maturity of rice (*Oryza sativa* L.) genotypes

| | Genotype | Control (NL) | Treated (LL) | Varietal Mean |
|--------|----------------|--------------|--------------|---------------|
| Early | LL-604 | 103.33 | 110.67 | 107.00 |
| | LL-609 | 102.33 | 108.33 | 105.33 |
| | Poornima | 88.67 | 93.00 | 90.83 |
| Medium | LL-612 | 112.67 | 118.67 | 115.67 |
| | LL-613 | 110.33 | 116.33 | 113.33 |
| | LL-614 | 115.67 | 118.33 | 117.00 |
| Late | LL-601 | 124.67 | 131.67 | 128.17 |
| | LL-602 | 129.33 | 135.33 | 132.33 |
| | LL-603 | 123.33 | 130.00 | 126.67 |
| | LL-605 | 128.33 | 134.67 | 131.50 |
| | LL-606 | 132.67 | 138.67 | 135.67 |
| | LL-607 | 133.67 | 139.67 | 136.67 |
| | LL-608 | 134.67 | 140.33 | 137.50 |
| | LL-610 | 133.33 | 138.67 | 136.00 |
| | LL-611 | 122.33 | 135.67 | 124.00 |
| | Treatment Mean | 119.68 | 126.00 | |

ANOVA Table

| Factors | C.D. | SE(d) | SE(m) |
|---------------|-------|-------|-------|
| Factor(A) | 0.260 | 0.129 | 0.091 |
| Factor(B) | 0.711 | 0.354 | 0.251 |
| Factor(A X B) | 1.006 | 0.501 | 0.354 |

Table 5: Effect of normal light (NL) and low light (LL) on plant height (cm) at flowering stage of rice (*Oryza sativa* L.) genotypes

| | Genotype | Control (NL) | Treated (LL) | Varietal Mean |
|--------|----------------|--------------|--------------|---------------|
| Early | LL-604 | 157.73 | 172.97 | 165.35 |
| | LL-609 | 104.90 | 126.23 | 115.57 |
| | Poornima | 107.17 | 113.67 | 110.42 |
| Medium | LL-612 | 103.73 | 112.60 | 108.17 |
| | LL-613 | 95.87 | 105.53 | 100.70 |
| | LL-614 | 104.27 | 107.27 | 105.77 |
| Late | LL-601 | 120.77 | 123.27 | 122.02 |
| | LL-602 | 109.73 | 110.20 | 109.97 |
| | LL-603 | 119.67 | 125.47 | 122.57 |
| | LL-605 | 128.17 | 145.13 | 136.65 |
| | LL-606 | 123.20 | 135.17 | 129.18 |
| | LL-607 | 115.40 | 147.53 | 131.47 |
| | LL-608 | 126.17 | 137.13 | 131.65 |
| | LL-610 | 137.70 | 138.00 | 137.85 |
| | LL-611 | 105.23 | 112.43 | 108.83 |
| | Treatment Mean | 117.31 | 127.51 | |

ANOVA Table

| Factors | C.D. | SE(d) | SE(m) |
|---------------|-------|-------|-------|
| Factor(A) | 0.389 | 0.194 | 0.137 |
| Factor(B) | 1.066 | 0.531 | 0.376 |
| Factor(A X B) | 1.508 | 0.751 | 0.531 |

Table 6: Effect of normal light (NL) and low light (LL) on number of leaves per hill at flowering stage of rice (*Oryza sativa* L.) genotypes

| | Genotype | Control (NL) | Treated (LL) | Varietal Mean |
|--------|----------------|--------------|--------------|---------------|
| Early | LL-604 | 93.88 | 74.16 | 84.02 |
| | LL-609 | 83.55 | 74.12 | 78.84 |
| | Poornima | 83.03 | 45.21 | 64.12 |
| Medium | LL-612 | 72.01 | 63.89 | 67.95 |
| | LL-613 | 92.03 | 68.79 | 80.41 |
| | LL-614 | 84.18 | 74.16 | 79.17 |
| Late | LL-601 | 73.82 | 67.24 | 70.53 |
| | LL-602 | 83.88 | 70.98 | 77.43 |
| | LL-603 | 72.20 | 52.15 | 62.17 |
| | LL-605 | 70.37 | 57.15 | 63.76 |
| | LL-606 | 85.74 | 84.29 | 85.02 |
| | LL-607 | 82.37 | 81.07 | 81.72 |
| | LL-608 | 92.03 | 89.10 | 90.57 |
| | LL-610 | 68.92 | 59.30 | 64.11 |
| | LL-611 | 66.22 | 51.39 | 58.81 |
| | Treatment Mean | 80.28 | 67.53 | |

ANOVA Table

| Factors | C.D. | SE(d) | SE(m) |
|---------------|-------|-------|-------|
| Factor(A) | 1.452 | 0.723 | 0.512 |
| Factor(B) | 3.976 | 1.981 | 1.401 |
| Factor(A X B) | 5.623 | 2.802 | 1.981 |

Table 7: Effects of normal light (NL) and low light (LL) on number of tillers per hill at flowering stage of rice (*Oryza sativa* L.) genotypes

| | Genotype | Control (NL) | Treated (LL) | Varietal Mean |
|--------|----------------|--------------|--------------|---------------|
| Early | LL-604 | 22.01 | 15.61 | 18.81 |
| | LL-609 | 17.51 | 15.90 | 16.71 |
| | Poornima | 16.22 | 9.62 | 12.92 |
| Medium | LL-612 | 14.60 | 13.34 | 13.97 |
| | LL-613 | 18.51 | 14.37 | 16.44 |
| | LL-614 | 20.54 | 17.29 | 18.92 |
| Late | LL-601 | 14.97 | 13.81 | 14.39 |
| | LL-602 | 20.45 | 16.23 | 18.34 |
| | LL-603 | 14.51 | 10.91 | 12.71 |
| | LL-605 | 14.43 | 12.03 | 13.23 |
| | LL-606 | 19.82 | 18.76 | 19.29 |
| | LL-607 | 19.48 | 18.48 | 18.98 |
| | LL-608 | 18.59 | 18.34 | 18.47 |
| | LL-610 | 15.05 | 12.07 | 13.56 |
| | LL-611 | 12.60 | 10.58 | 11.59 |
| | Treatment Mean | 17.29 | 14.49 | |

ANOVA Table

| Factors | C.D. | SE(d) | SE(m) |
|---------------|-------|-------|-------|
| Factor(A) | 0.272 | 0.135 | 0.096 |
| Factor(B) | 0.744 | 0.371 | 0.262 |
| Factor(A X B) | 1.053 | 0.525 | 0.371 |

Conclusion

The study clearly demonstrated the significant impact of light intensity on the growth and flowering behavior of rice genotypes. Exposure to low light conditions resulted in delayed flowering initiation, reduced growth rates, and extended maturation periods across all genotypes, with early, medium, and late varieties showing varying degrees of response. These effects were particularly evident in parameters such as plant height, leaf number, tillering, and

flowering time. While low light stress caused a reduction in tillering and leaf initiation, it also stimulated plant height. These findings underline the critical role of light in rice growth and highlight the importance of optimizing light conditions for enhancing rice productivity.

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