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Effect of different artificial light source on rice seedling quality under closed stereo cultivation

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Abstract. This paper designed an experiment for exploring the effect of the artificial light source on the rice seedling quality under closed stereoscopic cultivation. The experiment which the rice seedling of Dongnong 428 variety was conducted in the closed seedling breeding room with the automatically controlled environment. The factors examined included fluorescent lamp (TFL), LED fluorescent light (W), LED red light (R), LED blue light (B), and three different combinations of LED red light and LED blue light (R:B 3:1, R:B 5:1, R:B 7:1) in the experiment for cultivating the rice seedling. The cultivated rice seedling was compared with that cultivated using natural light (NL). An analysis method was proposed for evaluating the physiological index, the morphological index, and the mechanical index of the rice seedling. The comparison results from the average values of various quality indexes of rice seedling showed that the growth strength order of the rice seedling under different light conditions was W > NL > TFL > RB > R > B. Therefore, it is feasible to use artificial light instead of natural light to cultivate rice seedlings, which is more effective and practical than the conventional breeding practice.

Keywords-component; artificial light, rice seedling, stereo cultivation, automatic controlled environment .

1. Introduction

The single-layer seedling-raising mode and open environment of traditional greenhouses seriously affect the production efficiency and cultivation quality of the seedling and restrict the improvement of rice production capacity[1].90% of dry matter accumulation of seedlings comes from photosynthesis, which is mainly produced by light quality[2]. Therefore, light quality plays an important role in the growth and development of seedlings.

Reports have been increasing about the effects of different light qualities on the growth and development of rice seedlings. Ma et al[3] found that the main order of factors affecting the quality of rice seedlings was: red-blue light ratio> light intensity> seedling spacing. Sun et al[4] found that LEDs light source is feasible to cultivate rice seedlings. Zhang et al[5] found that the effects of light quality on the seedling index of two rice varieties much better than supplemental light. Guo et al[6] showed that under red light conditions, rice seedlings in the three-leaf stage have significantly improved compared with other light sources. Wang et al[7] found that LED red and blue monochromatic light irradiated rice seedlings for a long time will affect the normal growth of seedlings.Liu et al[8] found that the effect of light on the plant height and stem thickness of seedlings in a multilayer greenhouse in a PC board greenhouse is significant. Fu et al[9] showed that single-wave blue light was the best for the growth of rice seedlings when cultured under different light qualities; However, the growth environments in these experiments are greatly affected by the external climate. This makes that other environmental factors cannot be quantitatively and accurately controlled, thus result in the lack of certain reliability of the experimental results.

In order to solve the above problem, this paper proposed a new model of seedling raising. Fluorescent lamp (TFL) and LED light source were used to stereoscopic seedlings cultivation in a closed nursery built of insulating and heat insulating materials. It can automatically regulate andcontrol the environment of rice seedlings at different growth stages, which may provide a technology basis for the selection and control of light source for industrial seedling cultivation.

2. Materials and methods

2.1 Experiment materials and environment parameter

The experiment was conducted in a closed grow seeding room from May 2 to May 20, 2022. The light sources including fluorescent lamp (TFL), LED fluorescent light (W), LED red light (R), LED blue light (B), three different combinations of LED red light and LED blue light (R:B 3:1, R:B 5:1, R:B 7:1) were used in the experiment.

These light sources were composed by four light sources, which the whole seedling raising cycle are shown in the Table 1.And eight treatments were performed and repeated for three times. The raising seedling effect under different light sources was shown in the Figure 1. In the Figure 1, TFL is the fluorescent lamp light sources, NL is the natural light source, R is the LED red light source, B is the LED blue light source and W is the LED fluorescent light, respectively. And RB7:1, RB5:1 and RB3:1 are the 7:1, 5:1, 3:1 combinations of LED red light and LED blue light, respectively.

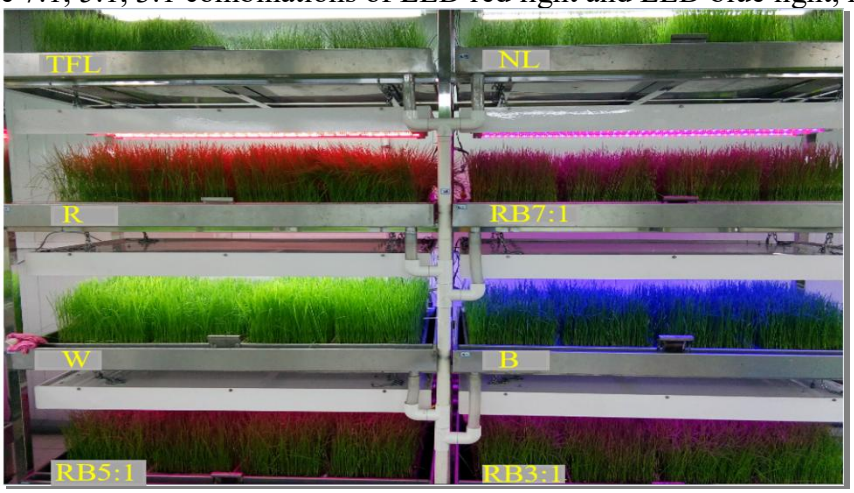


Figure 1. The raising seedling effect under different light sources.

Table 1. The experiment environment parameter Settings.

Growth cycle	Temperature ℃	Air humidity %	Soil moisture %	photoperiod h	pH	CO_2 concentration ppm
Seedling stage	32~34	60~70	/	/	4.5~5.5	450~500
Greening period	30~32	60~70	8~10	Bright 4h and dark 4h	4.5~5.5	600~650
One leaf and one hear period	28~30	60~70	8~10	Bright 6h and dark 2h	4.5~5.5	750~800
Two leaves and one heart period	26~28	60~70	14~16	Bright 6h and dark 2h	4.5~5.5	750~800

Three leaves and one heart period	22~24	40~50	14~16	Bright 6h and dark 2h	4.5~5.5	750~800
Seedling stage	16~18	40~50	8~10	Bright 4h and dark 4h	4.5~5.5	750~800

2.2 Seedling determination method

After lighting for 15 days, 10 seedlings were randomly selected from each row and each layer for indicator measurement, which were repeated for three times. The measured indicators include leaf length, root length, stem width, plant height, dry weight, stem tensile force and stem shear force.

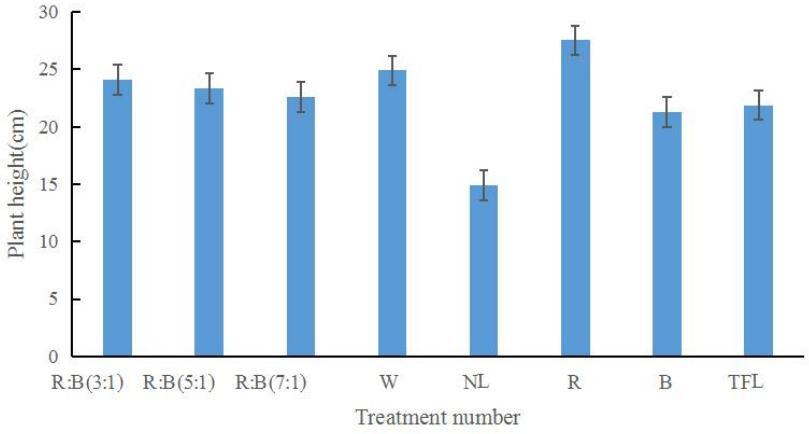
3. Results and discussions

3.1 Influence of different light sources on seedling shape

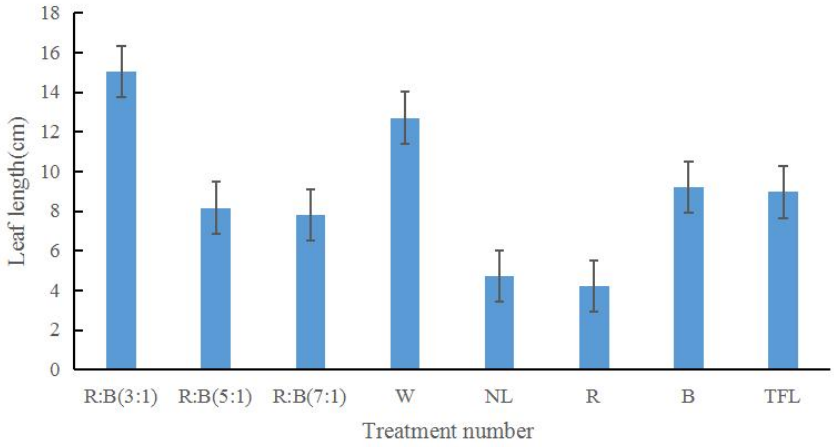
As shown in the Table 2 and Figure 2a, the different treatments had significant effects on plant height of rice seedlings compared with NL. The plant height of all treatments increased significantly. The plant height under R treatment was the highest and much higher than that under other treatments. And that under B treatment was significantly lower than that under the other six treatments. There was no significant difference in plant height between that under red and blue treatments. The results showed that rice seedling height was the highest under red light treatment, the second highest was under LED white light treatment. The lowest of rice seedling height was under blue light and fluorescent light treatment. The results showed that red light promoted the height elongation of rice seedlings, while blue light inhibited the growth of rice seedlings.

The leaf length of rice seedlings under different light treatments was significantly different compared with NL shown in the Table 2 and Figure 2b. The leaf length under red light treatment was significantly increased. The leaf length under RB3:1 and W treatment was the longest and much longer than that under other treatments. However, that under B treatment was the smallest, and there was no significant difference between other treatments. The results showed that the combination of red and blue light could promote the growth of rice seedling leaves under a controllable growth environment.

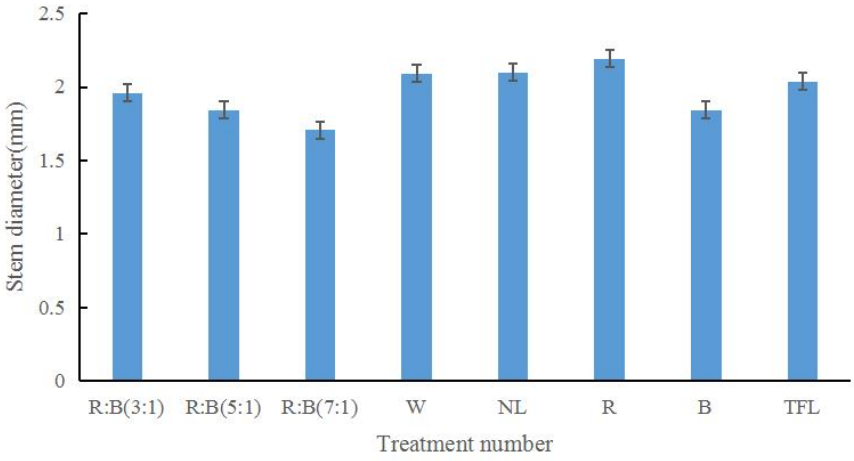
As shown in the Table 2 and Figure 2c, the stem diameter of rice seedlings decreased gradually with the increase of red light proportion in LED red-blue combination light. The stem diameter under R treatment is the thickest. The stem diameter under W treatment is slightly lower than that under NL treatment. However, the stem diameters under B, RB3:1, RB5:1 and RB7:1 treatments have no significant difference. The results showed that red light was beneficial to the thickening of rice seedling stem compared with other light sources. As seen from the above analysis, the growth rank of seedlings under different treatments was W > NL > TFL > RB > R > B.



a. The influence on plant height .



b. The influence on leaf length.



c. The influence on steam diameter.

Figure 2. The influence of different light sources on the seedling shape.

Table 2. The one-dimensional variance analysis of drawing force of stem.

Treatment number	Plant height/cm	Leaf length/cm	Number of root	Root Length/mm	Stem diameter/mm	Shear force of stem/N	Drawing force of stem/N
R	27.5a	4.2c	10b	62.20a	2.19a	2.0499A	9.38AB
B	21.3d	9.2b	9bc	60.19a	1.85b	1.8928A	8.81B

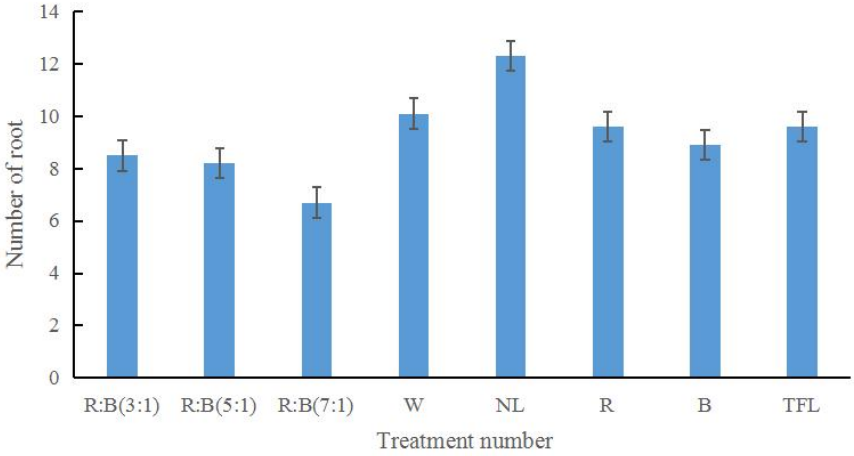
						B	
RB(3:1)	24.1bc	15.0a	9bc	59.72a	1.96ab	1.7457B	9.04AB
RB(5:1)	23.4c	8.2b	8bc	60.42a	1.84b	1.7555B	8.47B
RB(7:1)	22.6cd	7.8b	7c	57.98a	1.71b	1.5985B	7.47C
W	24.9b	12.7a	10b	63.38a	2.09ab	2.2181A	10.21A
TFL	21.9d	9.0b	10b	59.77a	2.04ab	1.9224AB	9.87AB
NL	14.9e	4.7c	12a	35.98b	2.10a	1.8046AB	8.69B

3.2 Influence of different light sources on seedling root

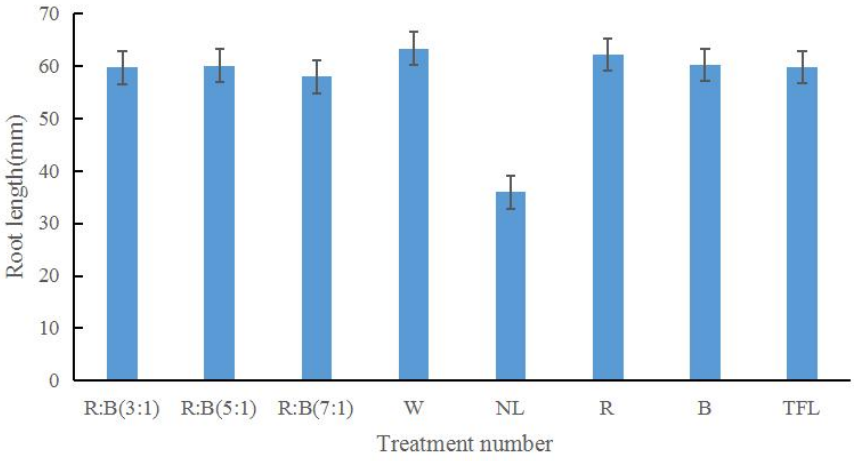
The effects of different light sources on the root growth of rice seedlings are shown in the Figure 3. There was no significant difference in root length among the treatments. The root length of rice seedlings under W treatment was the longest and that under R treatment was the second longest. However, there was no significant difference between the two treatments. The root length of seedlings under W treatment was significantly higher than those treated with B, R and RB. The root length of rice seedlings under R treatment was slightly larger than those under TFL, B and RB treatments. However, there was no significant difference among them. The results showed that monochrome blue light inhibited the growth of rice seedling roots.

4. Conclusion

By using single factor experiment and multiple comparison method, the influence of different light sources on seedling quality index was discussed. By comparing the average values of various indices of rice seedlings, the single factor variance analysis and multiple comparative analysis of each index were taken into account. The results showed that the order of growth strength of rice seedlings treated by different treatments was W > NL > TFL > RB > R > B. R treatment could promote the elongation of plant height, while B treatment could inhibit the growth of rice seedlings. R treatment was beneficial to the accumulation of biomass. The stem diameter of seedlings was positively correlated



a. The influence on root number.



b. The influence on root length.

Figure 3. The influence of different light sources on the seedling root.

with the stem pulling force, the dry weight of 100 plants and the stem shearing force. Appropriate artificial light source can improve the seedling quality.

5. Acknowledgments

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References

[1] Rattanamanee T, Ariyadet C, Sakhonwasee S, Daengprok W. Influences of LED light quality to rice seedlings green tea grown in a semi-closed system. Journal of Fundamental and Applied Sciences. 2018;(35):468–481.

[2] Chen C.C, Lin K.H, Huang M.Y, Huang W.D, Yang C.M. Effects of Light Quality on the Chlorophyll Degradation Pathway in Rice Seedling Leaves. 2016;(2): 393–398.

[3] Ma Xu, Lin Chaohui, Qilong, et al. Effect of different lighting quality and intensities on quality of rice seedling by greenhouse stereoscopic nursing [J]. Transactions of the Chinese Society of Agricultural Engineering. 2015(11):236-243.

[4] Sun Qingli, Chen Zhi, Xu Gang, et al. Effect of different light qualities on seedling growth in rice [J]. Acta Agriculturae Zhejiangensis. 2010, 22(3):0-325.

[5] Zhang Xijuan, Lai Yongcai, Meng Ying et al. Application of Red and Blue Light Source LEDs in Three-Dimensional Rice Seedlings [J]. Crops. 2014(5): 122-128.

[6] Guo Yinsheng, Gu Aisu, Cui Jin, et al. Effects of light quality on growth and physiological characteristics of rice seedlings [J]. Chinese Journal of Applied Ecology. 2011, 22(06): 1485-1492.

[7] Wang Guoli, Song Guanhua, Huang Suxing, et al. Effects of light-emitting diode (LED) red and blue light on seedling quality of different rice varieties [J]. Journal of Henan Agricultural Sciences. 2014, 43(10): 6-10.

[8] Liu Hongbo, Long Hanwei, Li Peiyuan, et al. Analysis of the Influence of Temperature and Light on the Growth of Seedlings in the PC Board Greenhouse [J]. Seed Technology. 2018, 36(04): 90-92.

[9] Fu Chuanming, Huang Ningzhen, Zhao Zhiguo, et al. Effects of light quality and supplemental light on rice seedling growth and photosynthetic rate [J]. Guihaia. 2007, 27(2):255-259.