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Effects of Different Artificial Light Sources on Mechanical Properties of Closed Stereoscopic Rice Seedlings

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Abstract. The effects of fluorescent lamp (TFL), LED fluorescent lamp (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) on the mechanical properties of rice seedlings were studied. The results showed that the stem diameter of seedlings was positively correlated with the stem pulling force, the dry weight of 100 plants and the stem shearing force.and the growth strength order of the rice seedling under different light conditions was W > NL > TFL > RB > R > B.Appropriate artificial light source can improve the seedling quality.

Keywords: artificial light, rice seedling,stem pulling force,stem shearing force.

1. Introduction

Light is one of the most important factors affecting plant growth and development,Light quality is an important factor of light, which affects the growth and development of plants to a great extent[1].The effects of different light quality on the growth and development of rice seedlings have been reported in many literatures,Wang et al[2] found that blue-violet light (400 ~ 480nm) was effective in the backlit growth of rice roots, while red light did not induce the backlit growth of rice roots.Zhang et al[3] found that the effects of light quality on the seedling index of two rice varieties much better than supplemental light.Guo Yinsheng et al[4] pointed out that red and blue LED is conducive to the cultivation of strong rice seedlings.Liu et al[5] 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.Studies have shown that the combination of red and blue leds can improve plant growth and development by increasing the net photosynthetic rate[6-9].

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 rice variety used in the experiment was Dongnong 428, which was provided by Northeast Agricultural University.The grow seeding room adopt two lines and four layers. Length, width and height of the room are 280cm, 73cm and 260cm, respectively. And the room was divided into eight seeding units. 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

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(R:B 3:1, R:B 5:1, R:B 7:1) were used in the experiment. And the experiment environment parameter settings was shown in table 1.

Table 1. The experiment environment parameter Settings.

Growth cycle	Temperature ℃	Air humidity %	Soil moisture %	photoperiodh	pH	CO2 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 mainly include stem tensile force and stem shear force. The determination methods of these indicators are as follows.

The determination of the drawing force of stem is follows as that a material drawing strength testing machine was used in the experiment.

The determination of the shear force of stem is follows as that that a universal testing machine was used in the experiment.

3. Results and discussions

3.1 Influence of different light sources on seedling mechanics index

The results showed that the stem tension of rice seedlings with different treatments was significantly different shown in the Table 2 and the Figure 1a.

The stem tension of rice seedlings under W treatment was the largest and that under TFL treatment was the second. The stem tension under R and RB3:1 treatment was better than that under B, RB5:1 and RB7:1 treatments. The stem tension under RB7:1 treatment was the smallest. There was no significant difference among R, RB3:1 and TFL treatments. It can be seen that the stem diameter of seedlings is positively correlated with the stem drawing force. Within a certain range, the thicker the stem base of seedlings is, the greater the stem breaking force is. The thicker the stem base is, the higher the fiber content is and the greater the tensile force is.

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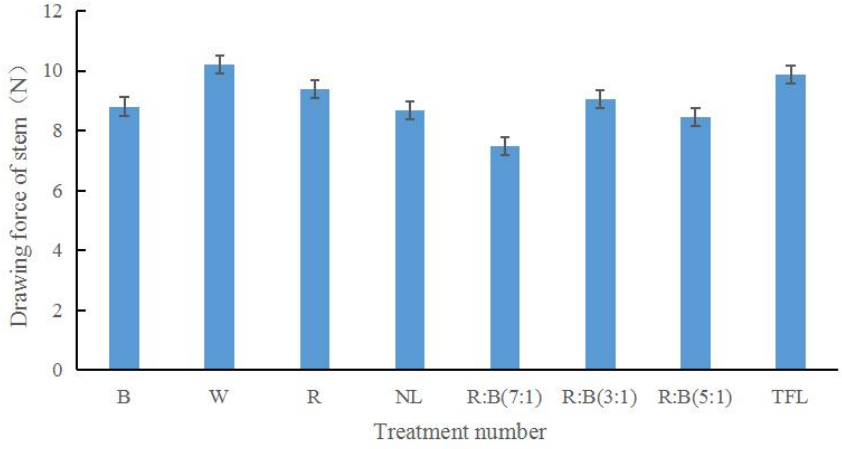
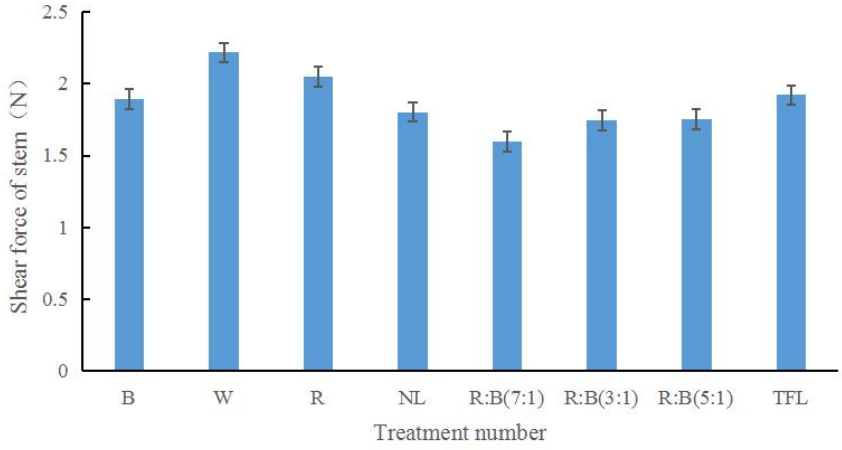
Table 2 The one-dimensional variance analysis of drawing force of stem

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	1.8928AB	8.81B
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



a. The influence on drawing force



b. The influence on shear force

Figure 1 The influence of different light sources on seedling mechanics index

From the Table 2 and the Figure 1b, it can be seen that the stem shear stress of rice seedlings under different treatments was significantly different. The stem shear stress of rice seedlings under W treatment was the largest and the second largest was under R treatment. The shear stress under TFL and B treatment was better than that under RB3:1, RB5:1, RB7:1 treatment. There was no significant difference between TFL and NL treatment. It can be seen that the dry weight of 100

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seedlings is positively correlated with the stem shear force. Within a certain range, the larger the dry weight of 100 seedlings, the greater the stem shear force.

3.2 Influence of stem diameter on drawing force

As can be seen from Table 2, except R and NL, the effects of the other groups on drawing force were significantly different (P <0.05), of which the W group was the largest at 10.21N. As shown in Figure 2, the stem diameter is positively related to drawing force (R2 = 0.9654). In a certain range, when the larger the stem diameter, the greater drawing force; when the larger the stem diameter, the higher the fiber content. The greater drawing force, the seedlings will not be easily broken during the transplanting process.

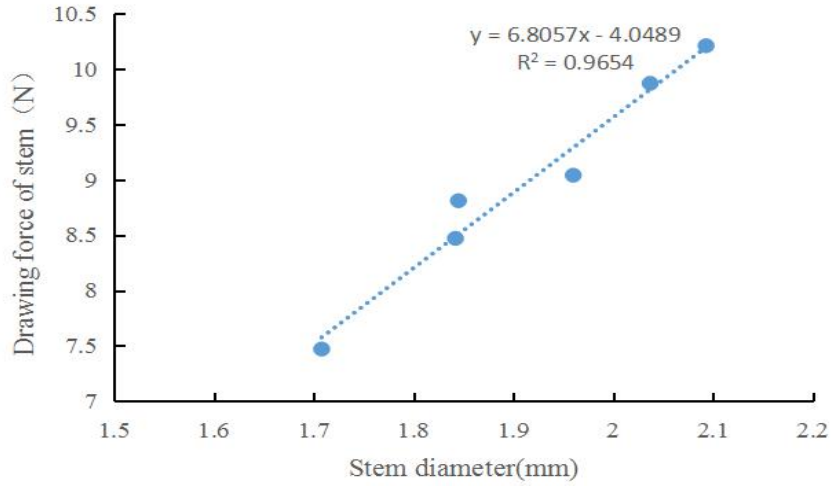

Figure 2 Correlation analysis of drawing force and stem diameter

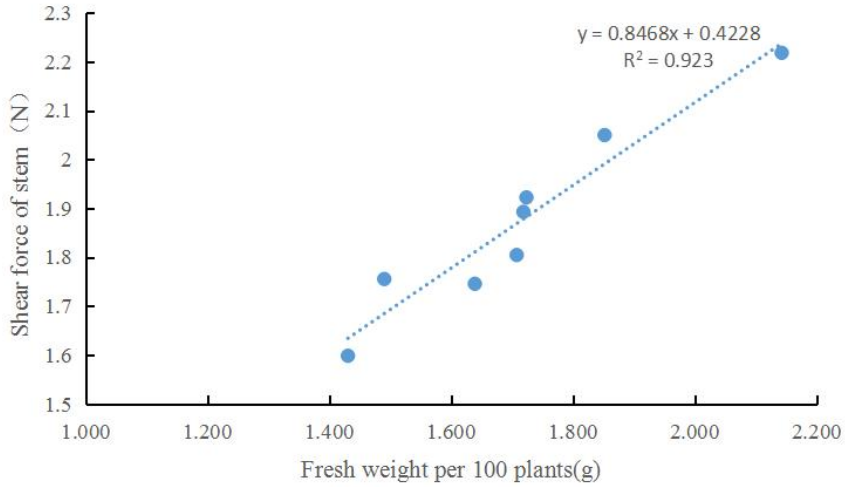

Figure 3 Correlation analysis of shearing force and fresh weight per 100 plants

3.3 Influence of fresh weight per 100 plants on shearing force

From Table 2 and Table 3, it can be seen that the effects of different treatments on shearing force were significantly different (P <0.05), of which the W group had the largest at 2.21N. As shown in Figure 3, the fresh weight per 100 plants is positively related to the shearing force (R2 = 0.923). Within a certain range, when the greater the fresh weight per 100 plants, the greater the shearing force; when the weight is large, the content of organic matter and cellulose are high, so the shearing force is large. Therefore, the plants are not easily pinched during the transplanting process.

Table 3 Result of sowing precision test

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Treatment number	Fresh Weight per 100 plants/g	Dry weight per 100 plants/g	Fresh weight of overground/ g	Dry weight of overground/g	Fresh weight of underground/g	Dry weight of underground/g
R	1.852b	0.347a	1.527a	0.298a	0.312g	0.048cd
B	1.719c	0.264d	1.041ef	0.203e	0.580b	0.053b
RB(3:1)	1.639e	0.280c	1.112d	0.227c	0.451d	0.049c
RB(5:1)	1.490f	0.218f	1.071e	0.181g	0.452d	0.037e
RB(7:1)	1.431g	0.196g	1.030f	0.164h	0.243f	0.030f
W	2.143a	0.302b	1.472b	0.249b	0.560c	0.047d
TFL	1.724c	0.266d	1.061ef	0.209d	0.603a	0.062a
NL	1.707d	0.249e	1.261c	0.199f	0.390e	0.048cd

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 stem diameter of seedlings was positively correlated 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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