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Short Communication

Effects of different light-emitting diode (LEDs) on fruit yield of greenhouse cucumber

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Cucumber (*Cucumis sativus* cv Delstar) was grown in greenhouse under different light-emitting diode (LEDs) to investigate the effects of different light waves on yield forms. Three treatments (red, Blue, and White) were conduct from 4 March 2008 to 24 June 2008. Results showed that, Blue light treatment got highest marketable production and marketable fruit ratio per plant, the value was 2309 g and 0.81 per plant, respectively. White treatment got lowest marketable production and marketable fruit ratio, with the value 1898 g and 0.12 per plant, respectively. However, White light treatment got highest single fruit weight with the value 166.99 g per fruit. From the above result, it may be of a good choice to use supplemental Blue light to increase cucumber production.

Key words: Cucumber, different light-emitting diode (LEDs), greenhouse, yield

INTRODUCTION

The concern for safe food and environment protection is increasing among consumers. Regulations on maximum residue limit in food are more and more strict. Production cost of vegetable could be reduced by adopting techniques with limited chemical use and alternative methods for sufficient pest and diseases control (Kittas et al., 2006). Greenhouse managers adopt many techniques to improve crop production and using light-emitting diode (LED) is one of them. Many researchers have pointed out that, different light qualities have a profound effect on plant growth (Jiang and Pan, 2006; Pu et al., 2005; Du et al., 2005), photosynthesis rate (Xu et al., 2005), fruit quality (Pu et al., 2005; Qi et al., 2007) and can also decrease insect and fungal diseases (Costa et al., 2002). Red light promoted the contents chlorophyll b and the growth of lateral shoots, and Blue light promoted the contents of chlorophyll a and inhibited the growth of lateral shoots (Jiang and Pan, 2006).

The economic yield of cucumber fruit is determined by the total fruit weight and fruit quality. An important quality aspect is the fresh weight of individual fruit with each size grade having a different market price (Marcelis, 1998). That is to say, not all picked fruit could be called yield. It is fruit that only reached a certain grade that can be sold at the market. However, no research has focused on fruit forms (single fruit fresh weight, marketable fruit weight, and marketable fruit ratio) under different light qualities

The objectives of this study was to investigate the response of cucumber plant to different light qualities in greenhouse and study the effect on yield forms, which can provide basic data for greenhouse production under weak light conditions.

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Table 1. The component of irradiance spectrum in different treatments (%).

Treatment (nm)	Red	Blue	White
300-400 nm	2.02 ± 0.14	4.23 ± 0.41	2.74 ± 0.12
400-510 nm	2.36 ± 0.14	20.35 ± 0.65	8.12 ± 0.24
510-610 nm	1.85 ± 0.12	54.62 ± 0.26	19.45 ± 0.92
610-710 nm	28.22 ± 0.56	14.85 ± 0.39	22.35 ± 0.38
710-1100 nm	65.55 ± 0.46	55.95 ± 0.67	47.34 ± 2.08
Solar radiation(w m^{-2})	155.8	155.3	157.2

Data presented are the averages of three greenhouses at a sunny day.

Table 2. Cucumber yield forms under different light treatment.

Parameter	Treatment			
	Red	Blue	White	$LSD_{0.05}$
Total fruit number per plant	29.3^{a}	29.1^{a}	28.9^{a}	3.89
Marketable fruit ratio per plant	0.67^{ab}	0.81^{a}	0.55^{b}	0.12
Marketable production per plant (g)	1996^{ab}	2309^{a}	1898^{b}	19
Mean fruit weight (g)	144.03^{b}	146.01^{b}	166.99^{a}	11.03

Data present are means of 6 plants, different letters in same row indicate significant difference ($p < 0.05$) for comparison between light treatments, respectively. $LSD_{0.05}$ is the least significant different for comparing different treatments under different treatments at $p = 0.05$ level.

MATERIALS AND METHODS

Plant material and growth conditions

The experiment was conducted at Multispan Venlo-type greenhouse of Shanghai Academy of Agricultural Sciences (Shanghai City, China) from 4 March to 24 June, 2008. Seeds of cucumber [*Cucumis stavius* L. cultivar 'Deltastar' (RIJKZWA, Netherlands)] were sown in plug (60 × 25 cm, 50 pots) filled with substrates on 10 February, 2008. Ten days after sowing, the seedling of cucumber was transplanted into substrates bags which were 3.3 m long and 0.3 m width and filled with perlite on 21 February, 2008, and plant density was 2.5 plant m^{-2}. Cucumber plants were fertigated using a trickle system and a Harrow fertigation manager. The EC of the feeding solution ranged from 2000 to 2500 μS cm^{-1} and PH was adjusted to 5.5 with nitric acid. To avoid water and nutrition stress, 20% excess nutrient solution was applied. Nine mini-greenhouses, all with the same size (4.4 × 2.6 × 3 m, L × W × H) were in one compartment, and its floor was covered with White plastic. Three of nine mini greenhouse were served to be supplied White light, and other were served to be supplied Red and Blue light, respectively. The LED lamps (provided by light and electricity graduate school of Fudan University, Shanghai City, China) were mounted on the greenhouse frames at 2.5 m above the ground, and turn on from 8:00 to 20:00. The component of spectrum in different mini-greenhouse was measu Red with a Li -1800 portable spectrum radiation meter (LI-COR, USA) at sunny day and the results are shown in Table 1.

Fruit harvest and quality analysis

In each treatment, 6 plants were randomly selected as measuring producing plant. Cucumber fruits of measuring producing plant were picked 7 times every week and graded according to the commercial standards. The number and fresh weight of each fruit were recorded.

Data analysis

Data were analyzed using the GLM procedure in the SAS 6.09 package (SAS Institute Cary, NC, USA) according to a split-plot experiment model. Means were separated with the protected t-test. The least significant difference (LSD) for mean separations was calculated according to the equations given by Cochran and Cox (1950).

RESULTS AND DISCUSSION

The effect of different light qualities on yield of greenhouse cucumber was shown in Table 2. Results showed that, no significantly difference was found on total fruit number per plant among 3 treatments. Compa Red with the White light treatment, the red, and Blue light treatment decreased mean fruit weight per fruit, but significantly increased marketable fruit ratio per plant. Thus, marketable fruit production per plant was still significantly increased, especially for the Blue treatment.

The yield of greenhouse cucumber was determined by assimilate production and the ratio of assimilate distributed to fruit. More deform and abortive fruits were observed in poor light condition than in sufficient light condition because of deficient assimilate. In order to gain more yield of greenhouse cucumber, it is necessary to increase the assimilate production.

Assimilate production was determined by the photosynthesis rate and the area of the leaf. Different light quality did show a profound effect on crop photosynthesis, leaf area and assimilate distributed. Blue and Red light can increase tomato leaf photosynthesis rate (Pu, 2005), the leaf thickness under Blue light treatment become thicker and thicker leaf can intercept more light than thinner leaf (Andrew et al., 1997). Red light treatment can enlarge leaf area (Pu, 2005). From the result, assimilate production was found to be higher in Red and Blue treatment than in White treatment, so the marketable fruit number per plant under Red and Blue treatment was higher that under White treatment. However, Red light can promote more assimilation distribute to stem (Moe and Morgan, 2002) and this account for the reason that, marketable fruit number under Blue treatment than that of Red treatment.

This is the first study on the effect of different light qualities on cucumber yield forms. Most of studies have focused on growth and development, photosynthesis, and decreasing insect and fungal diseases. Few reports have focused on effect of the different light qualities on crop yield forms with Pu (2005) reporting that, Blue light improve the first two truss yield.

Conclusions

The study assessed the effect of different LEDs on fruit yield of cucumber under greenhouse condition. The result showed that, supplemental Blue light can decreased the occurrence of deform and abortive fruit and thereby increased the market value of greenhouse cucumber in term of number and weight per plant. It is a good option for cucumber production.

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