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Influence of Illumination with Xenon or Sulfur Lamp on Growth of Tomato Seedlings

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Effects of illumination with xenon or sulfur lamp on growth of tomato seedlings were studied. Results showed no obvious differences in net photosynthetic rate and apparent quantum efficiency. In comparison with xenon lamp, illumination with sulfur lamp slightly reduced Chl a and Chl b content in leaves, relatively shortened epicotyl and hypocotyl length, but significantly increased anthocyanin content of leaves and promoted root growth of tomato seedling plants.

Key words: Xenon lamp, sulfur lamp, tomato, anthocyanin, hypocotyl elongation

INTRODUCTION

Light exerts great influences on plant photomorphogenesis. In seedling period, illumination should be carefully considered to get satisfying harvest. Xenon lamp and other HID lamps are universally used for agricultural purpose. Compared with these common lamps, microwave sulfur lamp already has been recognized to be energy saving light source internationally[1]. It provides a light spectrum similar to that of sunlight, reduces energy, and requires less maintenance. It has the characters of high efficiency, long life, continuous spectrum similar to that of sun but with very low UV and minimal IR irradiation, small radiate bulb, and no poison to environment. In this paper, different effects of illumination with xenon or sulfur lamp on growth of tomato seedlings, one of important vegetable crops, were studied.

MATERIAL AND METHODS

Experiments with tomato(cv. L402) were carried out from Oct in 2001 to May in 2002. Plump tomato seeds were soaked in tap water for 8 hours and planted in concocted soil(turf:earth=1:1,V/V) after germination. Plants were grown in growing container, illuminated with 160-180 μ mol photons $m^{-2}s^{-1}$ for 16h at 22℃and then kept in darkness for 8h at 18℃to finish one growing day cycle. Light intensity at the upper edge of container was measured with GGTM-1 photosynthetic photon flux density meter. Except lamps, all other management measures were the same.

Chl a, cha b content was measured following the method in Ref [2]. Anthocyanin content was measured according to the method in Ref [3].

Net photosynthetic rate and apparent quantum efficiency were measured with a CI-301 CO_2 Gas Analyzer using opening system under the growing condition, viz., PAR 160-180 μ mol photons $m^{-2}s^{-1}$, CO_2 concentration 410-430 μ mol mol^{-1}.

Fresh weight or dry weight was measured with following method: 5 plants were randomly chosen. Roots were washed clean with tap water, exterior water of plants was absorbed with tissue paper before measurement. Fresh roots, stems and leaves were cut and weighted with Yamato

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CY-300 electronic balance. Fresh samples were put into oven at 90℃ for 40min and then 70℃ for 12hr. During the process of dryness, samples were weighted at intervals of 2h. Dry weights were obtained when weights kept constantly.

Xenon and microwave sulfur lamp were developed and provided by the Electric Light Source Corporation, Fudan University.

RESULTS AND DISCUSS

It was observed that there was a significant difference in leaf color of tomato seedlings grown with xenon and sulfur lamp respectively. It was amaranthine for samples grown under sulfur lamp or viridescence under xenon lamp. Chl a、Chl b and anthocyanin content were measured afterwards. Results indicated that Chl a, Chl b content under xenon lamp were somewhat more than that under sulfur lamp (Table 1). Total content of Chl a and Chl b in leaves of plants grown under xenon lamp was 22.5% more than that of plants under sulfur lamp. By contraries, anthocyanin content in leaves of tomato plants grown under sulfur lamp was 746.1% more than that under xenon lamp, indicating that light composition of sulfur lamp promoted synthesis or accumulation of anthocyanin in leaves of tomato plants. In some plants, blue light is effective in inducing anthocyanin formation [4]. Because sulfur lamp is richer in blue light than xenon lamp, higher anthocyanin content of leaves under sulfur lamp possibly resulted from the light component. In addition, intensive infrared irradiation from xenon lamp might inhibit anthocyanin synthesis to some extent.

Effect of the two lamp on net photosynthetic rate and chlorophyll content were also investigated. Result showed no significant differences in net photosynthetic rates and apparent quantum efficiency between two samples grown with xenon or sulfur lamp.

Table 1. Effects of illuminations with xenon or sulfur lamp on pigment content and photosynthetic properties of tomato seedling leaves

Lamp	Chl a content (mg/g FW)	Chl b content (mg/g FW)	Chl a+b content (mg/g FW)	Chl a/Chl b	Anthocyanin (A_{530}/g FW)	Net photosynthetic rate (μmol CO_2 $m^{-2}s^{-1}$)	Apparent quantum efficiency
Xenon	1.66±0.08	0.79±0.04	2.45±0.13	2.11±0.05	2.43± 0.62	4.22±0.03	0.039
Sulfur	1.34±0.08	0.66±0.03	2.00±0.12	2.03±0.02	20.56±1.36	4.17±0.12	0.040

Table 2. The effects of illumination with xenon or sulfur lamp on fresh or dry weight of roots, hypocotyls and leaves of tomato seedlings, measured on the 18th day after seed planting*

Lamp	Fresh weight(g)				Dry weight(g)			
	Roots	Hypocotyl	Leaves	Total	Roots	Hypocotyl	Leaves	Total
Xenon	0.125	0.229	0.355	0.709	0.017	0.010	0.039	0.066
Sulfur	0.159	0.146	0.347	0.652	0.020	0.008	0.043	0.071

*All values were means of four randomly chosen individual seedling plants.

In order to understand effects of illumination with xenon or sulfur lamp on tomato vegetative growth, fresh and dry weight of roots, hypocotyl and leaves of tomato were measured on the 18th day after seed planting. Table 2 showed that total FW of a whole plant grown under xenon lamp was heavier than that grown under sulfur lamp. But opposite to this, total DW of whole individual plant under sulfur lamp was slightly heavier than that under xenon lamp, indicating that seedlings under sulfur lamp accumulated more dry matter. Apparently, fresh or dry hypocotyl weight of seedlings grown under xenon lamp was 56.8% or 25.0% heavier than that under sulfur lamp. However, fresh or dry root weight of seedling plants grown under sulfur lamp was 27.2% or 17.6% heavier than that under xenon lamp. There were no obvious difference in FW and DW of leaves. Results indicated that illumination with different lamp caused different distribution of dry matter among plant organs. Apparently, illumination with sulfur lamp especially

promoted root growth, but decreased hypocotyl elongation. Hypocotyls and epicotyls of tomato seedlings under xenon lamp were 27.0% or 19.0% longer than that under sulfur

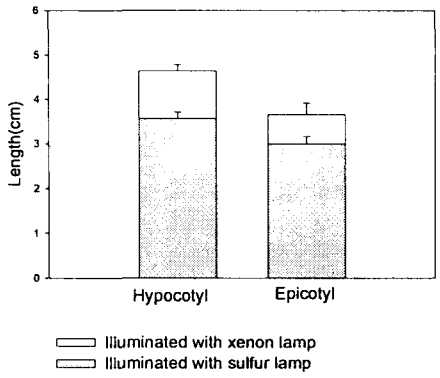

Figure 1. Effects of illumination with xenon or sulfur lamp on epicotyl and hypocotyl elongation of tomato seedlings.

lamp (Figure 1).

Observed from the experiments, tomato plants grown with sulfur lamp obviously demonstrated different photomorphogenesis than those grown under xenon lamp, having shorter epicotyl, hypocotyl and stronger root, and much richer anthocyanin content. Undoubtedly difference in light composition is the main cause for the morphological discrepancy of tomato seedlings. According to their spectra of the two lamp[1], xenon lamp has distinctly intensive infrared radiation in the region of 800-1000nm while sulfur lamp has minimal IR irradiation, so infrared radiation might be mainly responsible for the seedling morphological difference.

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