PROCEEDINGS

OF THE

35TH ANNUAL MEETING

25-31 July 1999

Castries, St. Lucia, W.I.

Proceedings Edited
By
Wilfredo Colón

Published by the Caribbean Food Crops Society

Proceedings of the Caribbean Food Crops Society. 35:200-204. 1999

RESPONSE OF SWEETPOTATO GROWN IN NUTRIENT FILM TECHNIQUE (NFT) TO BLUE LIGHT

D.G. Mortley, J.H. Hill, C.K. Bonsi, and W.A. Hill, Center for Food and Environmental Systems for Human Exploration of Space and George Washington Carver Agricultural Experiment Station, Tuskegee University, AL USA 36088

ABSTRACT. An experiment was conducted in controlled environment chambers to evaluate the effect of varying levels of blue light on vine growth and storage root yield of sweetpotato [*Ipomoea batatas* (L.) Lam.] when grown in nutrient film technique (NFT). Cuttings of 'TU-82-155" sweetpotato were grown under 6, 11, 16, 22.5, and 26% blue light (320-496 nm) supplied by high intensity discharge metal halide and high pressure sodium lamps. Total fresh mass was greatest for plants grown under 22.5 or 26% , and lowest for plants under 11% blue light. Total plant dry mass and storage root yield, however, were similar among treatments. Harvest index (storage root dry mass/total plant dry mass) was highest for plants grown under 26% blue light. Plants grown under 26% blue light tended to have a higher growth rate. Both vine and internode length tended to decline as the percentage of blue photons increased. These results indicate that storage root yield was not adversely affected by exposure to blue light as high as 26%, and that the main effect of blue light was to cause a reduction in vine length.

INTRODUCTION

Sweetpotato growth, nutrition, and physiology are being investigated at Tuskegee University as part of the National Aeronautics and Space Administration's (NASA) Advanced Life Support (ALS) research program, to provide food for long term and extended space missions. For extended space missions that will involve a large number of crew members, a life support system relatively independent of resupply from earth is envisioned. ALS technologies must regenerate air, water and food, manage and recycle wastes to achieve optimum resource recovery, and minimize involvement of the crew while assuring proper monitoring and control of essential systems. Plants are ideal candidates for use in an ALS because they meet the above mentioned criteria

The effects of light quality on sweetpotato growth and yield has not be studied, because it is a parameter over which the researcher can exert very little influence (Kays, 1982). However, increased research activity in controlled environment facilities (CE), has made it more practical to do research on radiation quality.

Blue light (320-496 nm) has been shown to affect plant photomorphogenesis processess such as: germination, flowering, and phenology (Sager, 1997). However, plant species differ in their sensitivity to blue light. Bugbee, (1994) reported no reduction in growth and yield of wheat under low pressure sodium lamps (LPS) vs high pressure sodium (HPS) or metal halide (MH) lamps. In contrast, soybean plants grown under HPS lamps showed reduced chlorophyll levels and chlorotic leaves compared to plants under MH lamps. Wheeler *et al.*, (1991) reported increased stem and internode lengths among soybean plants grown under HPS lamps but were progressively shorter with increasing supplemental blue light. Dougher and Bugbee (1998), reported that lettuce was highly sensitive to blue light and produced optimum dry weight and leaf area with about 6% supplemental blue light. Soybean and wheat did not respond to blue light, suggesting that blue light may not be beneficial for these two crops. The objective of this study was to determine the effect of increasing levels of blue light on growth and yield of sweetpotato plants.

MATERIALS AND METHODS

Vine cuttings (0.15 m long) of TU-82-155 sweetpotato were grown in 0.15 x 0.15 x 1.2 m NFT channels (Morris *et al.*, 1989) in controlled environment walk-in growth chambers (Environmental Growth Chambers, Chagrin Falls, OH). High pressure sodium (HPS) and metal halide (MH) lamps were used singly or in combination to provide 5, 11, 16, 22.5, and 26% blue photons. Growth chamber conditions included photosynthetic photon flux (PPF) of 1100 μmol $m^{-2}s^{-1}$, 70$\pm$5% RH, 14/10 h photoperiod, and a matching 28/22C thermoperiod

A modified half-Hoagland (Hoagland and Arnon, 1950) solution provided a 1:2.4 N:K ratio and solution pH was maintained between 5.5 and 6.0 by the addition of either dilute NaOH or HCl. Nutrient solution was replenished once or twice per week with a dilute (one-quarter) Hoagland stock. Solution was continuously pumped from each reservoir at 1 L min^{-1} to the high end of each channel by small magnetic drive pumps (Little Giant Model 2P037, Tecumseh Products Co., Oklahoma City, OK USA). Each vine cutting spaced 0.25 m within channels spaced 0.25 m apart (Mortley *et al.*, 1991) was held in place by a flat-plate assembly (Morris *et al.*, 1989) attached to the sides of the channel by a flexible white/black vinyl covering.

Plants were harvested after 120 days and all foliage was cut at the base of the plant. Lengths of the two longest vines, the number of nodes, and internode length from each plant were recorded. Plants were weighed fresh and dried for 48 h at 70C. A composite 25-g sample of storage roots from each of four plants per growth channel.was dried at 70C for 48 h. This information was used to calculate a fresh mass to dry mass conversion factor that was then used to convert measured fresh mass to determine storage root dry dry mass. Harvest index (HI; storage root dry mass/total plant mass) was also calculated.

The experiment was conducted as a randomized block design with two runs. Data were combined by treatment and and analyzed by the General Linear Models (SAS, 1985) procedure with mean separation by Duncans Multiple Range Test (5%).

RESULTS

Total plant fresh mass was not significantly affected by supplemental blue light (Table 1). However, plants grown under 16% supplemental blue light produced greater total dry mass than plants grown under 11% blue, and was similar to the other treatments. The number of storage roots was greatest for plants under 6% blue light and lowest at 11% and 22.5%. Storage root fresh and dry mass were similar among treatments, while percent dry matter and fibrous root dry mass were higher for plants grown under 16% supplemental blue light (Table 1).

When expressed on a fresh mass basis, growth rate was not siginificantly influenced by blue light (Table 2). However, when expressed on a dry weight basis, plants grown under 16% blue had a faster growth rate than plants grown under 11% blue, but rate was similar to the other treatrments. Neither edible fresh and dry mass, nor total foliage fresh mass were significantly affected by supplemental blue light. Foliage dry mass was significantly lower for plants grown under 11 or 22.5% supplemental blue. Harvest index was similar among blue light treatments (Table 2).

Vine length was greatest among plants grown under 6% blue light, declined as the percentage of blue photons increased, and was lowest among plants grown under 26% blue. Internode length decreased as the percentage of blue photons increased and was lowest for plants grown under 26% blue light. The mean number of nodes per plant was similar for plants grown at 6, 11, 22.5, and 26% blue light but significantly fewer for plants grown under 16% blue light.

DISCUSSION

These results demonstrate generally, that total plant mass or storage root yield were not reduced when grown under high pressure sodium or metal halide lamps, singly or in combination in a recirculating nutrient film technique hydroponic system. Storage root yield was similar among the treatments (Table 1). This occurred in spite of the fact that the number of storage roots tended to decrease as the percentage of blue light increased. This suggests that increasing the percentage of blue photons may result in fewer storage roots but has minimal effects on fresh or dry mass accumulation. In fact, plants grown under 16% blue light had a greater accumulation of dry mass (Table 2). Foliage fresh mass (Table 2) was similar among the treatments but differed in dry mass, while harvest index was not significantly affected by blue light treatments. Other reports (Bugbee, 1994; Dougher and Bugbee, 1997) have indicated differential sensivity of species to spectral quality. Both reports indicated that lettuce was highly sensitive to blue light fraction, whereas wheat and soybean were not. The fact that storage root yield, was not reduced, suggest that sweetpotato is relatively insensitive to growth under blue light.

The longest vines and internodes were obtained among plants grown under the lower percentage of blue light. Therefore, for both vine and internode length, it required at least 26% blue light to effect a reduction in length. Wheeler *et al.*, (1991) reported a reduction in stem and internode length of soybean with up to 30 μmol $m^{-2}s^{-1}$ supplemental blue light. It has been suggested that suppression of stem elongation in plants grown under blue light may be related to a blue/UV receptor (s) distinct from phytochrome (Wheeler *et al.*, 1991).

These results show that sweetpotato yields were not significantly reduced regardless of the percentage of blue light supplied. However, vine and internode length were reduced with increased percentage of blue light, but apparently did not affect partioning to storage roots. This suggests that supplemental blue light fractions may not be absolutely necessary for optimum growth and yield of sweetpotato.

ACKNOWLEDGEMENT

This research was supported by funds from the U.S. National Aeronautics and Space Administration (Grant No. NAGW-2940) and USDA/CSREES (Grant No. ALX-SP-1).

REFERENCES

Bugbee, B. 1994. Effects of radiation quality, intensity, and duration on photosynthesis and growth pp 39-50. In T. W. Tibbitts (ed.). Proc. International lighting in controlled environments workshop, Madison, WI. March, 1994.

Dougher, T.A.O., and B. Bugbee. 1998. Is blue light good or bad for plants? Life Support and Biosphere Science 5:129-136.

Hoagland, D.R., and D.I. Arnon. 1950. The water-culture method for growing plants without soil. Calif. Agr. Expt. Sta. Circ. 347.

Kays, S.J. 1982. The physiology of yield in the sweetpotato pp 79-132. In: J. Bouwkamp (ed.) Sweetpotato products: A natural resource for the tropics. CRC Press. Boca Raton, FL.

Morris, C.E., P.A. Loretan, C.K. Bonsi, and W.A. Hill. 1989. Movable root contact pressure plate assembly for hydroponic system. U.S. Patent 4860490. Date issued 29 Aug. 1989.

Mortley, D.G., P.A. Loretan, C.K. Bonsi, W.A. Hill, and C.E. Morris. 1991. Plant spacing influenced yield and linear growth rate of sweetpotato grown hydroponically. HortScience 26:1274-1275.

Sager, J.C.and J.C.McFarlene. 1997. Radiation. In: R.W. Langhans and T.W. Tibbitts (eds.) Plant growth chamber handbook. NCR Publ. Np. 340. Iowa State Univ. Press, Ames Iowa.

Wheeler, R.M., C.L. Mackowiak, and J.C. Sager. 1991. Soybean growth under high-pressure sodium with supplemental blue lighting. Agron. J. 89:903-906.

Table 1. Yield responses of hydroponically grown sweetpotato under varying levels of supplemental blue light[z].

Blue	Total plant mass		Storage root				
Light	fresh	dry	No.	Fresh mass	Dry mass	DM	Fibrous dry mass
%	——kg m^{-2}——		m^{-2}	——kg m^{-2}——		%	g m^{-2}
6	18.6a	2.61ab	82a	12.5a	1,572a	11.9ab	103.9b
11	16.0a	2.10b	47b	10.9a	1.261a	10.9b	90.3b
16	19.5a	3.02a	72ab	13.3a	1.946a	13.7a	126.9a
22.5	16.1a	2.26ab	51b	10.8a	1.398a	12.9ab	94.3b
26	17.1a	2.38ab	68ab	11.8a	1.493a	12.9a	92.9b

[z]Mean separation within columns by Duncans Multiple Range test (p=0.05).

Table 2. Growth rate, edible mass, foliage mass and harvest index of hydroponically-grown sweetpotato under varying levels of supplemental blue light[z].

Blue	Growth Rate		Edible Mass		Foliage Mass		Harvest
Light	Fresh	Dry	Fresh	Dry	Fresh	Dry	Index
%	------g $m^{-2}d^{-1}$------				------g m^{-2}------		
6	103.2a	14.5ab	69.5a	8.7a	4108a	938ab	57.9a
11	88.7a	11.7b	60.4a	7.0a	3368a	750c	62.1a
16	108.3a	16.8a	73.9a	10.8a	3948a	950a	61.7a
22.5	89.5a	12.5ab	60.2a	7.7a	3343a	764c	58.9a
26	95.1a	13.2ab	65.4a	8.3a	3546a	795bc	62.5a

[z]Mean separation within columns by Duncans Multiple Range test (p=0.05).