Proceedings of the Tenth Symposium of the International Society for Tropical Root Crops, held in Salvador, Bahia, Brazil, October 23-29, 1994

SELECTING SWEET POTATO (*IPOMOEA BATATAS*) CULTIVARS FOR HYDROPONIC PRODUCTION

C. Bonsi, P. P. David, D. G. Mortley,
P. A. Loretan, and W. A. Hill

Abstract

The sweet potato is one of several crops selected by the U.S. National Aeronautics and Space Administration (NASA) for food production in the 'Controlled Ecological Life Support Systems' for long-term space missions. The development of cultivars with consistently high yields and high DM, and adaptable to non-conventional production systems is essential if the cultivars are to provide the calories needed in the human diet. Studies were conducted both in the glasshouse and in environmental growth chambers to evaluate selected sweet potato germ plasm with high yields and high DM for adaptability to growth under the nutrient film technique (NFT). Vine cuttings of each cultivar were placed 25 cm apart and grown for 120 days, using NFT growing channels (0.15 x 0.15 x 1.20 m), each containing four plants of the same cultivar. Plants were supplied with a modified half-Hoagland nutrient solution. Average glasshouse conditions were 23-29 °C, 80% r.h., and daytime irradiance at 1000 μmol m^2 s^{-1}. Growth chamber conditions included a 14-h photoperiod; temperatures at 28 and 22 °C for light and dark periods, respectively; 350-720 μmol m^2 s^{-1} irradiance; and 70% r.h. Cultivar differences were observed, and several were identified as suitable for hydroponic production. Generally, the DM of the hydroponically grown sweet potatoes was reduced by 5%-15%, compared with field-grown plants.

Introduction

The Controlled Ecological Life Support Systems (CELSS) programme is a collaborative effort between the Tuskegee University and the U.S. National Aeronautics and Space Administration (NASA). A major objective is to develop systems and procedures for growing crop plants with subterranean edible parts in soilless culture. Studies at the Tuskegee University have used nutrient film techniques (NFT) as part of a hydroponic system for growing sweet potatoes. In this system, roots are exposed to a thin film of nutrient solution flowing in a plastic channel (Hill et al. 1989; Loretan et al. 1989). Studies have shown that potatoes, sugar beets, and peanuts—all crops with subterranean edible parts—can grow successfully in this NFT system. Hill et al. (1992) and Mortley et al. (1991), in their work on evaluating sweet potato genotypes for adaptability to hydroponic systems, showed that varietal differences exist for growth response in an NFT system. They also showed that the percentage of DM was not adversely affected by hydroponic culture.

To produce adequate dietary calories within a limited area for long-term space missions, crop plants selected for CELSS must be able to produce a high edible biomass with a high dry wt. To improve these properties for sweet potatoes, the Tuskegee University-NASA/CELSS Center initiated a germ plasm development programme to select field-grown sweet potato germ plasm with high DM and high yields. In our study, we screened selected germ plasm for adaptability to the NFT system.

Materials and Methods

The selected sweet potato cultivars were grown in the glasshouse in a randomized block design with two replicates. Four 15-cm vine cuttings of each cultivar were planted 25 cm apart in standard Tuskegee University NFT channels (0.15 x 0.15 x 1.20 m). Plants were supplied with a modified half-Hoagland nutrient solution with a 1:2.4 N-to-K ratio. Solution pH was maintained between 5.5 and 6.0 by adding either NaOH or HCl. Solutions were changed every 2 weeks and topped with de-ionized water if the volume fell below Sl before the 2-wk change. The nutrient solution was pumped by a small submersible pump (Teel Model 1P680A, 1/200HP Dayton Electric, Chicago) from each reservoir to the top of each channel set at a 1% slope. The solution flowed back into the reservoir as a thin film at a rate of 1 L/min. Glasshouse conditions were 23-29 °C, 75%-95% r.h., daytime irradiance of 600-1000 μmol m^2 s^{-1}, and 12-16 h photoperiod. For the experiments conducted in the growth chamber, conditions were 14-h photoperiod, 28/22 °C for light/dark, 350-720 μmol m^2 s^{-1} irradiance, and 70% r.h. A similar experimental design as in the glasshouse was used, but only two cultivars (Jewel and TUJ1) were used because of limited growing space.

All experiments were terminated at 120 days after planting (DAP). Plant foliage was cut at the base and weighed when fresh and when dried (for 72 h at 70 °C). Storage roots for each plant were separated, counted, and weighed fresh. Four 25-g samples were then taken and dried at 70 °C for 72 h to determine DM. Fresh and dry weights of fibrous roots were determined per plant, using similar procedures. Each experiment was run twice, and data were combined for analysis, using ANOVA, with mean separation by Duncan's multiple range test (DMRT) at $P < 0.05$.

Results and Discussion

Table 1 illustrates the results of the glasshouse and growth chamber experiments. The glasshouse studies showed significant differences in growth in the NFT system among cultivars for all growth parameters measured. Mortley et al. (1991) observed similar results when they tested 14 sweet potato genotypes in an NFT hydroponic system.

In Experiment 1, cv. J8/14 produced a significantly higher number of storage roots per plant than did the other cultivars, except I13/11. Similarly, in Experiment 2, cultivars PX32 and J8/17 produced a significantly higher number of storage roots per plant than did PX31 or PX33.

In Experiment 1, the highest fresh and dry weights of storage roots were produced by

J6/5. These were, however, statistically comparable with the storage root yields of cultivars J8/14 and TUJ1. Cultivars derived from the I13 accessions (I13/11, I13/18, and I13/13) produced the lowest fresh and dry weights of storage roots. The storage root yield in Experiment 1 ranged from 73 to 620 g/plant for fresh wt and 11 to 164 g/plant for dry wt. In Experiment 2, yields were relatively lower than those in Experiment 1. Yield per plant ranged from 79 to 249 g for fresh wt and 25 to 79 g for dry wt. Highest yields per plant were produced by cv. J8/17 (249 g fresh and 79 g dry); and the lowest by PX33 (79 g fresh and 25 g dry).

Dry matter in storage roots in Experiment 1 ranged from 12.5% (cv. I13/13) to 30.2% (cv. TUJ1). In Experiment 2, DM content was generally higher than those found in Experiment 1, ranging from 25.5% to 31.7%. The DM content of the cultivars tested in both experiments was lower than that observed in the same cultivars under field conditions, at a 5%-15% difference. These observations are, however, contrary to those by Loretan et al. (1988) and Mortley et al. (1991), who found no adverse effect on DM content between hydroponically and field-grown sweet potatoes.

In Experiment 1, except for cv. AC87.8/16, which produced the highest fresh and dry weights of foliage, no significant differences were observed among the cultivars in the amount of foliage produced. Similar results were observed in Experiment 2, with PX33 producing the highest amount of foliage. Eight of the cultivars tested showed an inverse relationship between foliage dry wt and storage root dry wt. Mortley et al. (1991) made similar observations for 11 of 14 genotypes.

Although statistical analyses were not performed for the growth chamber studies, data indicated that cv. TUJ1 produced a higher number of storage roots, with higher fresh and dry wts and a higher DM content, than did ‘Jewel’. Fresh and dry wts of fibrous roots and foliage, however, were lower (Table 1). Both cultivars showed an inverse relationship between foliage dry wt and storage root dry wt.

Overall, the results of these studies agree with the earlier studies conducted by Mortley et al. (1991), which showed that several sweet potato cultivars have high potential in NFT production. Although DM content was adversely affected when sweet potatoes were grown in the NFT system, the DM of the selected cultivars was still generally higher than that of conventionally grown sweet potatoes that had not been selected.

Acknowledgements

This research was supported by funds from the George Washington Carver Agricultural Experiment Station, Tuskegee University (Contribution No. PS403); NASA (Grant No. NAGW-2940); and USDA/CSRS (Grant No. ALX.SP.1).

References

Hill WA; Loretan PA; Bonsi CK; Morris CE; Lu JY; Ogbuehi C. 1989. Utilization of sweet potatoes in Controlled Ecological Life Support Systems (CELSS). Adv Space Res 9:29-41.

Hill WA; Mortley DG; MacKowiak CL; Loretan PA; Tibbitts TW; Wheeler RM; Bonsi CK; Morris CE. 1992. Growing root, tuber and nut crops hydroponically for CELSS. Adv Space Res 12:125-131.

Loretan PA; Bonsi CK; Hill WA; Ogbuehi CR; Mortley DG; Lu JY; Morris CE; Pace RD. 1989. Sweetpotato growth parameters, yield components and nutritive value for CELSS applications. SAE Tech Paper Ser 891571.

Loretan PA; Morris CE; Bonsi CK; Hill WA; Pace RD; Lu JY; Biswas PK. 1988. Sweetpotato production in hydroponic systems. In: Proc. International Congress on Soilless Culture, 7th Flevonhof, Netherlands, 13-21 May. ISOSC, Wageningen. p 275-287.

Mortley DG; Bonsi CK; Loretan PA; Morris CE; Hill WA; Ogbuehi CR. 1991. Evaluation of sweetpotato genotypes for adaptability to hydroponic systems. Crop Sci 31:845-84.

Table 1. Growth response of various sweet potato cultivars growing in the nutrient film technique (NFT) system in the glasshouse and growth chamber.[a]

Cultivar	Storage roots				Fibrous roots (dry wt in g/plant)	Foliage	
	No.	Fresh wt (g/plant)	Dry wt (g/plant)	Dry matter content (%)[b]		Fresh wt (g/plant)	Dry wt (g/plant)
A. Glasshouse experiments							
Experiment 1							
J8/14	5.9 a	505 ab	94 b	18.1 b (25.4)	13.5 cd	455 ab	42 b
I13/11	4.5 ab	292 c	72 bc	24.3 ab (29.2)	15.6 c	523 ab	61 ab
J6/19	3.9 bc	349 bc	83 b	23.6 ab (30.0)	13.2 cd	600 ab	69 ab
TUJ1	3.6 bc	517 ab	162 a	30.2 a (--)	21.5 b	594 ab	86 ab
J6/5	3.4 bc	620 a	164 a	25.1 ab (30.5)	10.3 d	628 ab	85 ab
AC7.8/16	2.5 cd	288 c	69 bc	21.7 b (39.8)	20.6 b	650 a	104 a
I13/18	0.9 d	73 d	11 d	16.4 cd (23.6)	11.3 cd	297 b	48 b
I13/13	0.6 d	175 cd	24 cd	12.5 d (23.8)	30.2 a	575 ab	95 a
Experiment 2							
J8/17	2.2 ab	249 a	79 a	31.7 a (40.9)	-	349 b	-
PX31	1.3 c	188 b	48 b	25.5 a (43.6)	-	293 b	37 b
PX32	4.3 a	235 ab	64 ab	27.2 a (32.0)	-	454 ab	54 ab
PX33	1.2 c	79 c	25 c	31.2 a (33.0)	-	527 a	77 a
B. Growth chamber experiment							
Jewel	3.2	428	105	24.5	24.6	761	92
TUJ1	6.5	554	159	28.7	12.4	689	81

a. *Means separated in columns within experiment, using DMRT; Means followed by the same letter within an experiment are not significantly different (P = 0.05).*

b. *Dry matter content (%) of field-grown sweet potatoes.*