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Performance of Sweetpotato for Bioregenerative Life Support

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Introduction

Sweetpotato (Hill et al. 1992) was grown to harvest maturity within NASA Johnson Space Center's Variable Pressure Growth Chamber (Barta and Henninger 1996) to characterize crop performance for potential use in advanced life support systems as a contributor to food production, air revitalization and resource recovery. Characterization of crop performance on a large-scale in closed atmosphere chambers is essential to advance the readiness level of crop plants as candidate biotechnologies for advanced life support (Wheeler and Strayer 1997). Data obtained from this research will be useful for systems modeling and analysis in support of development of biomass production systems for the Bioregenerative Planetary Life Support Systems Test Complex (Barta et al. 1999) as a stepping stone to the development of technologies for long duration human exploration of space.

Methods

Stem cuttings of breeding clone "TU-82-155" were grown hydroponically at a density of 17 plants m^{-2} using a modified pressure-plate growing system (Patent No. 4860-490, Tuskegee University) within the Variable Pressure Growth Chamber (Figure 1). Lighting was provided by HPS lamps at a photoperiod of 12h light:12h dark. The photosynthetic photon flux was maintained at 500, 750 and 1000 $\mu mol\ m^{-2}\ s^{-1}$ during days 1-15, 16-28 & 29-119, respectively. Canopy temperatures were maintained at 28°C light:22°C dark. During the light period relative humidity and carbon dioxide were maintained at 70% and 1200 $\mu l\ l^{-1}$, respectively. Nutrient solution was manually adjusted 2 to 4 times per week by addition of 10X concentrated modified half-strength Hoagland nutrient salts and NaOH to return the electrical conductivity and pH to 1.2 mS cm^{-1} and 6.0, respectively.

Results & Discussion

At 17 weeks (119 days) from transplanting, a total of 56.5 kg fresh mass of storage roots (84.1% moisture) were harvested from the 11.2 m^2 chamber resulting in a yield 5.0 kg m^{-2} (Table 1, Figure 2). Harvest index, based on fresh mass, was 38.6%. Proximate nutritional composition of the storage roots was generally similar to values reported for field-grown sweetpotato except moisture and ash content were higher (USDA, see also Wheeler 1999). Once canopy closure occurred, canopy net photosynthesis averaged 0.5 kg $CO_2\ d^{-1}$ over the entire 11.2 m^2 crop which would support approximately one-half the air revitalization requirement for one person. The transpiration rate, following canopy closure, ranged from 300 to 450 ml $m^{-2}\ hr^{-1}$ during the light period and 100 to 150 ml $m^{-2}\ hr^{-1}$ during the dark period. Disruption of the crop canopy during chamber entries to take measurements and during episodes of nutrient stress affected gas exchange and transpiration.

Conclusions

Sweetpotato was successfully grown to harvest maturity in a large-scale atmospherically-closed controlled-environment chamber. Yield of edible biomass and capacity for contributing to air revitalization and water recovery were documented. Yield was slightly less than that found in smaller-scale studies, but this is not unusual (Wheeler 1999). Continued work is suggested to improve control of storage root initiation, bulking and vine growth.

Literature Cited

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Index Terms Advanced Life Support, Biomass Production, Sweetpotato, Photosynthesis, Yield, Transpiration

Table 1. Biomass partioning in sweetpotato at harvest (17 weeks from transplanting).

Crop Component	Fresh Mass (kg m^{-2})	Dry Mass (kg m^{-2})
Storage Roots	5.05	0.80
Leaves, Stems, Vines	5.37	1.23
Fiberous Roots	2.14	0.11
String Roots	0.12	0.01
Stem & Stem Waste	0.27	0.04
Total Crop Biomass	12.95	2.18
Harvest Index	0.39	0.37
No. of Storage Roots*	281	281

*Includes all storage roots greater than 1 cm. in diameter

Table 2. Proximate analysis of sweetpotato storage roots at harvest.

		Composition Based on Dry Mass			
Grade	Moisture %	Ash %	Protein %	Carbohydrate %	Fat %
No. 1 (5.1-8.9 cm diameter)	83.8	4.3	3.7	91.4	<0.6
Jumbo (>8.9 cm diameter)	85.2	4.0	4.7	90.6	<0.7
Canner (2.5-5.1 cm diameter)	84.4	4.4	5.1	89.2	1.3
Culls (1-2.5 cm diameter)	84.9	5.3	5.3	88.8	<0.7
Field-grown (USDA)	72.0	3.3	5.9	89.6	1.1

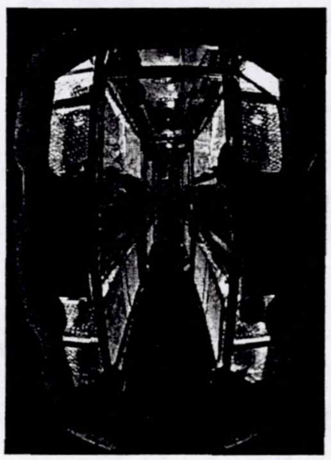

Figure 1. View through open door of the VPGC shortly after planting. There are eight growing areas, four on each of side of the chamber, in two levels. Perforated aluminum sheet was to contain the sweetpotato vines during growth.

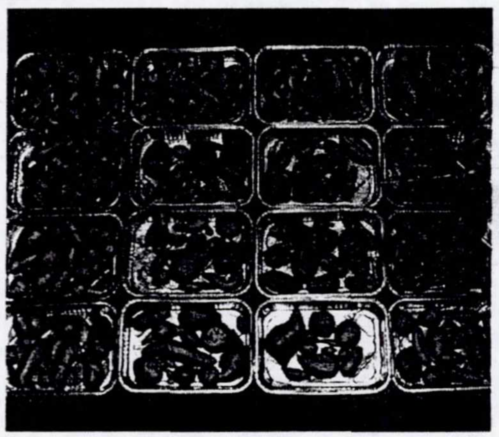

Figure 2. Harvested sweetpotatoes from one-half of the chamber (5.6 m^2)