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Veronica E. Walton

Tuskegee University, vwalton@tuskegee.edu

Raymon Shange

Tuskegee University, rshange@tuskegee.edu

Victor Khan

Tuskegee University, vkhan@tuskegee.edu

James E. Currington

Wiregrass RC&D Council

Ramble Ankumah

Tuskegee University, rankumah@tuskegee.edu

~~See next page for additional authors~~
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Authors

Veronica E. Walton, Raymon Shange, Victor Khan, James E. Currington, Ramble Ankumah, Edward Sparks, Nathaniel Ellison, George X. Hunter Jr., and Jeffery L. Moore

YIELD OF TWO SWEETPOTATO (*IPOMOEA BATATAS* (L.) CULTIVARS GROWN IN A WIREGRASS MODEL TUNNEL HOUSE UNDER TRELLISED AND CONVENTIONAL PLANTING SYSTEMS

***Veronica E. Walton¹, **Raymon Shange¹, Victor A. Khan¹, James E. Currington²,
Ramble Ankumah,¹ Edward Sparks¹, Nathaniel Ellison¹, George X. Hunter¹,
and Jeffery Moore¹**

¹Tuskegee University, Tuskegee, AL; ²Wiregrass RC&D Council, Ozark, AL

***Email of lead author: vwalton@tuskegee.edu**

****Email of corresponding author: rshange@tuskegee.edu**

Abstract

The study was conducted in a Wiregrass Model Tunnel House to evaluate the response of two sweetpotato cultivars (“Carver” and “TU-1892”) and two different planting methods (Conventional and Trellised) at S & B Farm in Eufaula AL., during the summer of 2015. Sweetpotato varieties were the main plots and planting methods were the subplots, each treatment combination was replicated four times. Results indicated that there were significant interactions between sweetpotato varieties and planting methods for US#1, Canners, and total marketable yield. There were also significant differences between varieties and planting methods for Canners and between varieties and total marketable yield. The results indicated that the response of sweetpotatoes under tunnel house conditions maybe varietal related, and influenced by high ambient temperature prevalent in tunnel houses during the summer months. Further studies will be required to test other varieties of sweetpotatoes and to evaluate impact of heat stress on root production.

Keywords: Tunnel House, Sweetpotato Varieties, Sweetpotato Yield, Planting Systems

Introduction

Tunnel Houses (THs) since its early introduction (Wells, 1993; Khan et al., 1994) are increasing in popularity among small-scale vegetable producers who see it as a viable alternative of extending their growing season through the cold and cool months of the year (Blomgren and Frisch, 2007). Due to the success that many growers experience in planting Brassica and other cool season crops such as leaf lettuce, beets, and carrots in their THs during the cold season, several have expressed their intentions of utilizing their THs year round. Because of the short day length in the fall and winter seasons, the TH does an excellent job of maximizing the “Greenhouse Effect” and provides very favorable growing conditions during this time of the year. However, these favorable winter growing conditions can soon have a negative impact on plant growth because of the longer days of summer, and the closeness of the earth to the sun. Therefore, the “Green House Effect” now becomes a disadvantage because the temperature range inside the TH can become very unfavorable for the growing of many crops economically (Johnson, 2011).

Regardless of the unfavorable growing conditions which exist in THs during the summer months, TH growers and extension agents are requesting summer planting recommendations for TH. Since sweetpotato is known for its ability to withstand heat and drought conditions, it was selected to determine how some varieties of sweetpotato would respond under TH conditions during the summer growing period. Therefore, the main objective of this study was to determine how best to grow sweetpotatoes in a TH and how this will impact selected factors. The specific objectives were

to (1) compare a trellis growing system with the conventional bed method of planting, and (2) determine how storage root yields would be impacted under TH conditions.

Literature Review

Tunnel houses (THs) are low-cost structures which can be framed from wood or metal tubing and covered with clear polyethylene plastic. These structures are unheated and not cooled like greenhouses. However, the clear plastic sheeting transmits the sunlight which creates the “Greenhouse Effect” thus warming the soil to 65-70°F, and this raises the ambient temperature within the TH to 15-20°F above that of the outside ambient temperature (Khan et al., 1994; Blomgren and Frisch, 2007; USDA NRCS., 2014). In addition to the modification of the ambient and soil temperatures, TH offers many other advantages such as increased yields, production of a quality crop, conservation of water, decreased insect and disease stress, and protection of plants from high winds and heavy rainfall thus protecting plants from many foliar diseases (Knewton et al., 2010).

TH research findings have reported very favorable yield results for several vegetable crops such as: turnips (*Brassica rapa*), collards (*Brassica oleracea*), cabbages (*Brassica oleracea var capitata*), Broccoli (*Brassica oleracea var botrytis*), and tomatoes (*Lycopersicon esculentum* (Mill.)), when grown during the winter or early spring (Wells, 1993; Khan et al., 1994; Khan et al., 2013). These improved yields are due in part to the more favorable temperature conditions in the TH which modifies the plant micro-environment by creating a favorable root zone temperature. Improved root zone temperatures lead to the stimulation of soil microbes which plays an important role in nutrient absorption by the plants (Diaz-Perez et al., 2008).

The favorable temperature regime which exists in the TH during the cold and cool months of the year soon becomes unfavorable as summer approaches. The very high temperatures which can exist in TH during the summer months can decrease photosynthesis, increase respiration, and reduce transpiration, if the temperature climbs above 94°F resulting in plant growth inhibition (Johnson, 2011). Furthermore, the high summer temperatures within TH can increase the soil temperature within the TH, which could lead to high root zone temperatures that can affect plant root growth, and enzymatic activities (Diaz-Perez et al., 2008).

The sweetpotato is a relatively heat tolerant crop which is grown mainly in the southeastern United States during the summer months where it requires a frost-free growing period of 110 to 150 days. Sweetpotatoes are traditionally grown in fields on bare soil, and since 1989, sweetpotato production in North Carolina has accounted for nearly 40% of U.S. output followed by Louisiana, and Mississippi (Offner and Jim, 2004). Following early studies where low density polyethylene (LDPE) black plastic mulch (BM) was used to evaluate some warm season crops such as cantaloupes (Wilson et al., 1987), similar studies using (BM) were conducted to evaluate the response of sweetpotatoes. Results from these studies (Brown et al., 1998; Hochmuth, 1983; Khan et al., 1999;1996) indicated increased sweetpotato root yields as well as above ground plant biomass; thus, indicating that this crop may do well in TH.

Materials and Methods

Tunnel House

This study was conducted during the summer of 2015 in a Wiregrass TH located at S & B Farm in Eufaula AL. A TH is defined as a low cost Quonset structure made from wood or metal, polyethylene pipes, and covered with clear greenhouse plastic film, without any supplemental heat or cooling. All planting is done directly in the soil and not in raised beds or containers.

The TH has several special characteristics which include the following: (1) it is framed entirely of wood with black polyethylene tubing for rafters; (2) it has roll up canvas curtains for the sides which allow ventilation; (3) it has and roll up doors, and (4) it is covered with 6 mils clear greenhouse plastic. The dimensions are 48 ft. long X 20 ft. wide, giving a gross area of 960 sq. ft. and a net planting area of 828 sq. ft.

Soil Type

The soil type at the study site is characterized as Norfolk sandy loam (fine, siliceous, thermic Typic, Paleudults). Recently, the soil has been reclassified as Kinston fine-sandy loam (fine-loamy, siliceous, semiactive, acid, thermic Fluvaquentic Endoaquepts) (USDA, 2004).

Tunnel House Site Preparation

The site was rototilled with a mechanical rototiller. After this, raised beds were prepared and shaped manually with a wooden mold. Each plot was 16 ft. X 1 ft. in dimension. At the time of preparation, a NPK (13-13-13) mix of fertilizer was banded in each plot, based on soil test recommendations. All rows were orientated in a North/South direction, and all plots were side dressed with muriate of potassium at 65 days after transplanting. Plastic tube drip irrigation lines (Chapin Drip Tape) were then placed in the center of each bed to provide irrigation water to the plants, and the beds were all covered with white on black plastic mulch. All plots were irrigated for two hours every other day until the end of the study at 120 days after transplanting according to the methods described by Khan et al. (1996).

Experimental Planting Materials

Five-inch-long vine plugs of “TU-1892” and “Carver,” which were raised in the greenhouse in plug trays for four weeks, were transplanted 12 inches within plots for a total of sixteen plants per plot. A 2” PVC pipe was used to punch holes through the plastic mulch in which the plugged sweetpotato transplants were planted. Weeds growing between rows and on beds were manually controlled.

Field Experimental Design and Data Collection

All plots were arranged into a randomized complete block design with a split plot arrangement and four replications per treatment (Snedecor, 1966). The main plots comprised of the cultivars (“TU-1892” and “Carver”) while the subplots consisted of the planting methods Trellised vs. Conventional planting systems based on four treatment combinations, namely, Carver trellised grown, Carver conventional grown, TU-1892 trellised grown, and TU-1892 conventional grown.

Galvanized 16 ft. 4-gauge cattle panels were used for the trellises. They were supported by 6 ft. metal poles spaced 5 ft. apart. Trellising of the plants began at 45 days after transplanting (DAT), and was continued weekly up to two weeks before harvesting. In addition, at 45 DAT a piece of plastic mulch 15’ long and 8” wide was removed from around the plants in each treatment of the study, to reduce risk of predisposing the storage roots to soft rot diseases (Khan et al., 1999).

Harvest Procedure and Statistical Analysis

At 120 DAT, all treatments were harvested by first removing the panels, vines, and the remainder of the plastic mulch. Plants were then manually dug up with a garden spade, and storage roots graded into the following grades: US#1, Canners, Jumbo, and Culls. Total marketable yield was then obtained by combining US#1, Canners, and Jumbo yields, while total yield was obtained by combining total marketable yield, and culls (USDA AMS, 2005). Each grade was then weighed and counted by treatments and all data were analyzed using Factorial Analysis of Variance with mean separation by Fisher's F test (Snedecor, 1966).

Results and Discussion

Tables 1 and 2 show significant differences among varieties for the yield of US#1 and Canner grades of sweetpotatoes harvested from conventional and trellised planting systems. "TU-1892" showed higher yields when grown on conventional planting compared to a trellis system. While the variety "Carver" showed a lower overall yields when compared to "TU-1892" but performed better when grown on a trellis system. However, both varieties also showed a significant interaction with planting methods. Figures 1 and 2, show the direction and magnitude of the interactions for both grades of sweetpotatoes. "TU-1892" showed the higher yield between the varieties irrespective of growing systems, compared to "Carver." The low yield of "Carver" for both grades of sweetpotatoes was due in part to the malfunctioning of the drip irrigation system where field rodents constantly chewed the irrigation lines thus disrupting the distribution of moisture to the plants, and the high air temperature present in the TH. Khan et al. (1994) reported that the ambient temperature in the TH was 20°F higher than the outside air temperature, and this increase in temperature caused by the "Greenhouse Effect" could have placed the sweetpotato plants under stress, by increasing their respiration and transpiration processes. The malfunctioning of the irrigation along with the increased temperature also aided in suppressing the yield of "Carver" more than that of "TU-1892" (Johnson, 2011).

Table 3 shows that "TU-1892" had the highest marketable yield under the conventional planting system compared to "Carver." Again, the varieties showed a significant interaction with planting methods. The direction and magnitude for the interactions for marketable yield (Figure 3) was similar to those for US#1 and Canner yields (Figures 1 and 2). A difference in the response of the two varieties which was revealed during the course of the study but was not an integral part of the experiment, was the leaf/vine canopy structure of the varieties. Both varieties produced a large amount of vines, however, "Carver" individual leaves had a greater leaf area than "TU-1892."

This difference in leaf area development between these varieties could have created in the TH a situation where the plants became crowded, and in the case of "Carver" because of its larger leaf area, mutually shaded a larger number of its own leaves compared to "TU-1892." In a recent article by TaoLi et al. (2014) they reported that close spacing of sorghum in the field suppressed photosynthesis of the leaves and restricted light intensity resulting in poor yields. Although these parameters were not a part of this study future studies of growing sweetpotatoes in TH should address these factors.

Table 1. Mean Yield of US#1 (Bu/acre) from Two Varieties of Sweetpotatoes Grown Under Two Growing Systems in a Tunnel House at Eufaula, AL 2015

Varieties	Planting Methods	
	Conventional	Trellised
TU-1892	341	311
Carver	0.88	44

Sig. of F Test From Anova

Varieties

**

Planting Methods

NS

Varieties X Planting Methods Interaction

**

***Significant at the 1% level; NS = not significant

Table 2. Mean Yield of Canner Grade (Bu/acre) of Sweetpotatoes from Two Varieties Grown Under Two Growing Systems in a Tunnel House at Eufaula, AL 2015

Varieties	Planting Methods	
	Conventional	Trellised
TU-1892	287	99
Carver	27	27

Sig. Of F Test From Anova

Varieties

**

Planting Methods

**

Varieties X Planting Methods Interaction

**

***Significant at the 1% level; NS = not significant

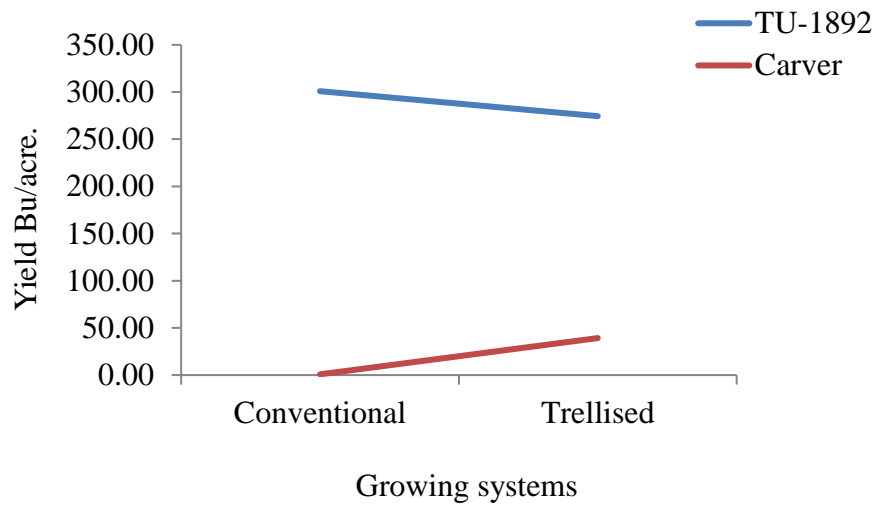


Figure 1. Two sweetpotato cultivars showing a significant interaction for US#1 yield between varieties grown in a tunnel house under two different growing systems.

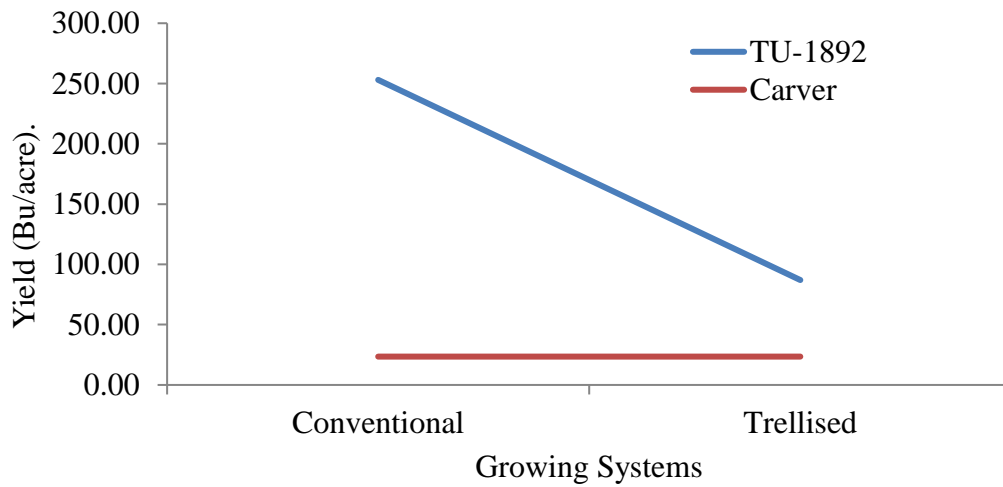


Figure 2. Significant interaction between sweetpotato varieties and two growing systems for Canner grade sweetpotatoes

Table 3. Mean Marketable Yield (Bu/acre) From Two Varieties of Sweetpotatoes Grown Under Two Growing Systems in a Tunnel House at Eufaula, AL 2015.

Varieties	Planting Methods	
	Conventional	Trellised
TU-1892	627	410
Carver	27	71

Sig. Of F Test From Anova

Varieties	**
Planting Methods	**
Varieties X Planting Methods Interaction	**

***Significant at the 1% level

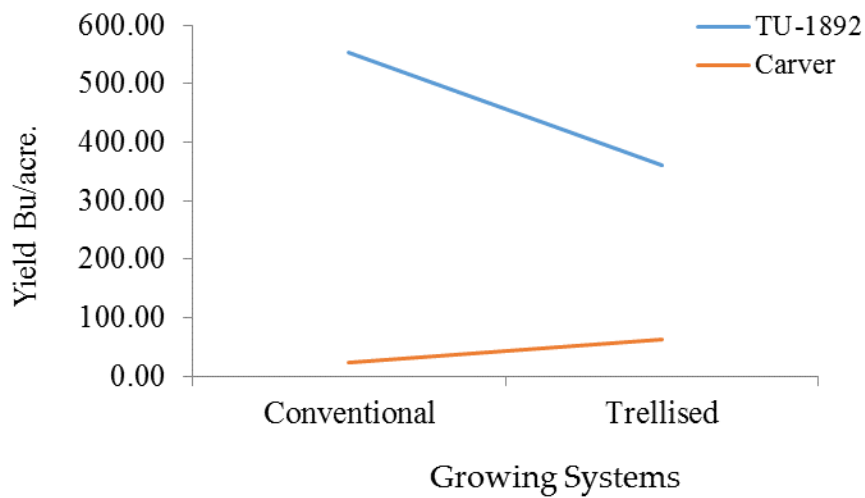


Figure 3. Significant interaction between varieties for marketable yield when grown in a tunnel house under two different growing systems.

Conclusion

The results from this study have shown that the sweetpotato has the potential to be a suitable crop to be grown in TH during the hot summer months providing that irrigation is adequate. The yield data was varietal dependent and contingent upon growing the sweetpotatoes under conventional or a trellised system. Since the response of the two varieties of potatoes used in this study was so different, additional studies are needed to evaluate, first, the response of other varieties of sweetpotatoes under TH conditions; second, what impact mutual shading and reduced light intensity would have on yield, and lastly, the best planting dates, because time of planting is known to affect yield.

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