Investigating the Impact of Plant Spacing on Yields of Sweet Potato Produced in Organic Systems

Final report for GS17-175

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Project Information

Summary:
The goal of this research project was to investigate the impact of plant spacing on yield performance of sweetpotato varieties in an organic management system in Tennessee and to share our findings with farmers, researchers and stakeholders. The sweetpotato crop is increasing in popularity. Partly due to its nutritional value, wide range of flesh-color types being introduced from all over the world, low cost of production, ability to grow well on marginal lands with little amounts of water and its sweet taste. The sweetpotato fresh markets and processing industries are enlarging as a result of the development of new and improved value-added products. Sweetpotato production in Tennessee, however, is believed to have declined since 1980 and currently certified organic sweetpotato production is below consumer demand. A preliminary trial was conducted in the fall of 2017 on the certified organic research farm at Tennessee State University, Nashville, Tennessee. The effect of 12” in row plant to plant spacing on the yield performance of cv. Beauregard, Centennial and Covington was measured. A randomized block design was implemented using 36” wide beds with 72” spacing between rows and cultivars. Cultivars were grown with strict adherence to the rules of the national organic standards board (NOSB). Data was collected on the sizes and yields of sweetpotato. Marketable yields were highest in the Covington followed by the Beauregard and Centennial varieties respectively. Of the three varieties, Covington also had the highest U.S. no 1 and least number of U.S. no 2, Meanwhile jumbo-sized roots were observed only in Beauregard cultivar. In the summer of 2018 the effects of 8”, 12”, 14”, 18” and 24” row plant spacing on the yield performance of cv. Beauregard, Evangeline and Covington was measured and compared. An increase in sweetpotato yields was observed with increased plant spacing. The effect of plant spacing on
yields was highly significant (p<0.001). The highest marketable yield overall was observed in the Beauregard (35, 719 lbs/acre) cultivar with a 24” plant spacing. The findings from this study contribute to and help fill in existing knowledge gaps on how yield production of various sweetpotato cultivars in sustainable farming systems are affected by differences in plant spacing. Information gathered was shared with farmers, researchers and stakeholders during small farm expo, field day and conference presentation.

Project Objectives:

1. Determine the impact of the plant spacing pattern on yield and sizes of three sweetpotato varieties grown in an organic management system.
2. Access the effect of five plant spacing patterns (5”, 8”, 12”, 18” and 24” in-row) on yield and sizes of three sweetpotato varieties grown in an organic management system.
3. To disseminate information of project findings with researchers, Tennessee’s small and minority growers through TSU’s Cooperative Extension Agents, Small Farm Expo, field demonstrations, fact sheets, and social media videos.

Cooperators

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Research

Materials and methods:

Accomplishments/Milestones

- Materials and supplies ordered and literature relevant to project work gathered in preparation for the second field trial.
- Hiring of project personnel was made to assist with project logistics and data collection
- Field plot of first field trial was set up in the summer of 2017 and maintained as needed (weeding, irrigation, harvesting) and data was collected at the end of growing period after harvesting.
- Field plot maintained after harvest and soil samples sent for analysis at soil science laboratory from field areas.
- Sweetpotato slips planted in green house in October 2017. Animal manure, vermi-compost and cover crop planting done on the field after first cycle to prepare land during fallow period.
- Slips for second trial procured in early 2018 from certified organic grower.
- Slips planted in the field and maintained per National Organic Program standards. Data collected after harvest in fall of 2018.
Variety trial/first cycle 2017

- Cover crops such as buckwheat and clover (Johnny’s selected seeds Winslow, ME) was applied in late fall each year proceeding planting to stifle weed germination and improve organic matter content in the soil.
- Land was cultivated, ploughed and prepared for planting using a bush hog, a tractor roto-tiller on 5/23/17. Ridger and bed maker used to make furrows on 5/25/17. The soil tilled and raised beds formed.
- Labels depicting treatment and variety were prepared.
- Slips of Beauregard, Covington and Centennial transplanted from readily available raised slips from the preceding years growing season in greenhouse pots and then transferred to field in summer 2017.
- A randomized block design employed of 10 plants in each cultivar spaced 12” apart in-row. Each sweetpotato bed was 36” wide with 108” spacing in-between the beds or rows. A 108” spacing was placed between each variety and row.
- Drip irrigation system was set up and wheat straw mulch cover laid.
- Weeding by hand in between plants and with the tractor in between the beds at intervals throughout the growing season.
- Field was observed for incidences of pest and disease in growing season.
- Shortly before harvest, sweetpotato vines were trimmed, and roots harvested with potato digger on 10/9/17 and placed into labelled boxes.
- Data collection commenced after sorting and grading roots as per USDA standards into different groups in the marketable and cull category.
- Curing of sweetpotato roots was for 7 days immediately after harvest at 85 F, 80–90% relative humidity before storage.

Variety trial/second cycle 2018

- 2018 field experiment was conducted at Tennessee State University Certified organic research farm to determine the ideal plant spacing for three varieties Covington, Evangeline and Beauregard.
- All three varieties are commercially grown in southern region for the fresh market and processing industries.
- The effect of five plant spacing (5”, 8”, 14”, 18” and 24”) on yields and sizes of the three varieties stated above was evaluated.
- Field plot was marked out on a different side of the field plot from last growing season (crop rotation), land was prepared was prepared about 4 weeks prior to planting and sweetpotato slips were purchased from certified vendors.
- Before planting, plastic mulch covering was laid mechanically by a mulcher, with drip tape underneath to mat down firmly to the soil on the research field plot.
- Planting was done on June 1, 2018. Plot size was 113’ by 72’. Bed width was 4’ with 6’ spacing between beds. Total of 10 plants per variety in each row was cultivated.
- A randomized complete block design with five treatments and three replications employed.
- Organic compost applied to field plot 2 weeks after planting.
- Weeding was done by hand and hoeing in between plants and with the tractor in
between the beds when required at intervals throughout the growing season.

- Field plots were maintained in organic management practices as per standards of National Organic Program throughout the planting season (Anonymous, 2015).

- Sweetpotato roots graded according to US grading standards, marketable roots at least 3.81 cm in diameter with no spots or disease and cull roots that may be injured, cracked, damaged or prone to quick spoilage (Anonymous, 2005).

- On October 1, 2018 roots were harvested with a potato digger (Spedo Inc., Castagnaro, Italy). After data collection, two-way analysis of variance (ANOVA) and tukey’s multiple comparison was made using Graphpad 8.0. (GraphPad Software Inc., San Diego, CA) to determine significant influences (? < 0.05) of variety and spacing on yields. The mean results on root size was analyzed in triplicates and presented.

Research results and discussion:

Objective 1: For the 2017 variety trial, soil sample analysis was made. Roots were counted, sorted, weighed with digital scales (Berry hill supplier, TN) and graded as per United States Department of Agriculture (USDA) standards. A general review (regardless of plant spacing, or location) was made to find out what the yields were of cultivars (Beauregard, Centennial and Covington) cultivated using conventional management practices in literature and to compare them with our results in organic production system. The average marketable root yield of sweetpotato (12" plant to plant spacing) from the TSU, Organic Farm Nashville, TN was then compared to conventionally produced sweetpotato available in literature regardless of plant spacing and location.

On analysis, the average soil pH of our field plot was determined to be 6.1. Soil organic matter was 2.33%. Supply of the nutrients phosphorous (534 lb/acre) and potassium (376 lb/acre) was very high in the soil and further application of the nutrients was not recommended, since further additions may have created nutrient imbalances. The availability of the secondary/micro nutrients i.e. Calcium (3211 lb/acre), Magnesium (225 lb/acre), Zinc (8.3 lb/acre), Iron (22 lb/acre) and Manganese (31 lb/acre) were found to be sufficient and in an adequate supply for plant utilization.

Our results showed that average marketable yields of sweetpotato in organic management systems was highest in Covington (35864.4 lb/acre) followed closely by Beauregard (35428.8 lb/acre). When compared with the conventional yields accessed from literature, yields of Beauregard (29924.19 lb/acre) sweetpotato were however higher than in Covington (28402.38 lb/acre). In both organic and conventional production systems, Beauregard and Covington yields were higher than the Centennial cultivar (organic-24829.2 lb/acre; conventional-12037.66 lb/acre). Overall, our results showed that the average marketable yields of sweetpotato yields produced on the organic farm (using a 12” plant to plant spacing) at Tennessee State University were on the average higher than yields of similar cultivars produced in conventional farming systems where spacing and location was not considered.

Furthermore, in this study, sweetpotato roots were also sorted into the cull or unmarketable roots category. Of the three cultivars tested, the least quantity of unmarketable roots was observed in Beauregard at only 7% while in Centennial it was recorded that 36% of the harvested roots was unmarketable. Centennial was
followed closely by Covington where 25% of its total yield were culls. According to USDA standards, sweetpotato cultivars were sorted into different groups. Covington had no Jumbo-(9438 lbs./acre) sized roots, Covington had the least quantity of US no 2 (871.2lbs./acre) root sizes and the highest amount of US no 1 petite (13213 lbs./acre) and US no 1 (21780 lbs./acre) sized roots when compared to the two other cultivars. Only the Beauregard cultivar contained Jumbo (9438 lb/acre) sized roots. The highest quantity of US no 2 (4792 lbs./acre) sized roots, including the least amount of US no 1 petite (6824 lb/acre) and US no 1 (8712 lb/acre) roots amongst all three cultivars tested was observed in the Beauregard cultivar.

Objective 2: A second trial was initiated in the summer of 2018 to evaluate the impact of 5, 8, 14, 18 and 24 in row spacing on organic sweetpotato yields of Beauregard, Evangeline and Covington cultivars. No fertilizer was used in this study. Water was supplied as needed using a drip irrigation system. The ANOVA results indicated that varietal total and marketable yields however increased with increase in plants spacing (p<0.05). Neither varieties or the interaction between varieties and plant spacing was significant.

Figure 1: Effect of 5”, 8”, 12”, 18” and 24” plant spacing on Beauregard, Evangeline and Covington sweetpotato total, marketable and cull root yields. Total yield (p=0.0003) was significantly higher (Figure 1a and 1b) in the 24” Beauregard cultivar (38, 115 lb/acre) when compared to the 5” spacing yields of Beauregard (6207 lbs/acre) and Covington (9002 lbs/acre). Beauregard cultivar and 24” plant spacing also varied significantly from the 8” plant spaced Beauregard (7405 lbs/acre) and Covington (5720 lbs/acre). Similar variance in plant spacing was observed in marketable sweetpotato yields (p=0.0004) with an additional significant difference between the 24” Beauregard (35719 lbs/acre) and 8” Evangeline (8639 lbs/acre) yields. There was no significant difference in unmarketable or cull yields amongst the various cultivars tested (Figure 1c).

Figure 2: Effect of 5”, 8”, 12”, 18” and 24” plant spacing on Beauregard, Evangeline and Covington US no. 1 petite (Canner) sweetpotato root yields. ANOVA results showed that in the Canner root category, the variety (p=0.015) and plant spacing (p=0.0453) influenced the diameter of individual roots. Plant spacing alone exerted a main effect on weights of the individual sweetpotato roots in the canner category (p=0.0021). The average diameter between the Covington and Beauregard canner sweetpotato roots, both cultivated with 12” plant spacing, differed significantly (Figure 2a). Covington at 12” plant spacing was significantly larger in diameter than the Beauregard individual canner roots produced with the same spacing. Individual canner roots of Covington at 8” plant spacing weighed significantly more than the Evangeline roots grown with 18” plant spacing (Figure 2b). The individual root length between all canner roots of all sweetpotato cultivars tested did not vary significantly (Figure 2c).

The use of black plastic mulch which is known to warm the soil and improve plant growth may have played a role in the increased yields obtained our study as well as a possible increase in storage root weight and size with increased plant spacing (Figure 3). Other possible reasons for yield outcomes could be the different varietal canopy structures or responses to black plastic mulch cover. Similar results were observed by Wees et al. (2016) in a study in Canada where the use of biodegradable plastic mulch with different plant spacing saw an increase in yield with increased
In the case of certain cultivars, like Evangeline (Table 1), higher US no. 1 petite (canner) root yield was observed at 5” plant spacing when compared to Beauregard and Covington. Thus reduced spacing might be responsible in part and beneficial for increased yields in certain cultivars when compared to others. U.S no. 2 sized sweetpotato was recorded only in the Beauregard cultivar. In addition, higher canner yield was obtained in Beauregard at 18” and 24” than all other cultivars tested. Similar studies was performed extensively by Arancibia et al. (2014). In conclusion, although 12” to 18” inch sweetpotato plant spacing is used commonly by growers, experimenting with 24” plant to plant spacing or more is encouraged for greater sweetpotato produce.

References


Participation Summary

Educational & Outreach Activities

9 Consultations
20 Curricula, factsheets or educational tools
3 On-farm demonstrations
3 Tours
1 Webinars / talks / presentations
2 Workshop field days

PARTICIPATION SUMMARY:
50 Farmers
16 Ag professionals participated

Education/outreach description:

POSTER PRESENTATIONS


FIELD DAY


3 On-farm demonstrations
3 Tours
66 Farmers

A tour of the organic sweetpotato field and variety trial was held shortly before harvest in the Fall of 2017. Participants included growers, researchers and stakeholders. Findings from research trials shared at the 2018 SARE conference in April at St. Louis MO. In July 2018, Tennessee State University summer farm expo gathered small-farm producers, students and researchers from Tennessee and 300 participants attended the expo and farm tours held. Positive feedback from attendees received on survey form. Results from this study presented at the regional meeting of Southern Region American Society for Horticultural Science. In addition, we held several on-farm visits from students, growers and individuals with a general interest on organic sweetpotato cultivation and production.

Project Outcomes

6 Farmers reporting change in knowledge, attitudes, skills and/or awareness

Project outcomes:

Sweetpotato total and marketable yields increased with increase in plant spacing, with 5” plant spacing producing the lowest yields and 24” highest. Overall, there was no significant difference between cultivars in response to plant spacing. There was a main effect of variety and spacing on diameter of individual canner roots. 18” spaced Evangeline produced canner roots with a longer diameter than that of Covington at 8” plant spacing. The individual canner root weight among cultivars varied (varietal effect). Canner roots of Covington weighed more than Beauregard canner roots at 12” plant spacing. The result of this study provides sweetpotato growers with desired information on yield performance of the crop, grown with different plant spacing, in organic farming systems, to adequately measure market value and hence profitability.

Knowledge Gained:
In sweetpotato production, higher plant spacing results in better root yield.

Recommendations:

Further studies are encouraged in other locations under varying growing conditions to see if similar results would be obtained.

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