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Effect of in-row spacing on weed suppression and yield of 'Covington' and 'Monaco' sweetpotato

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Abstract

Organic sweetpotato growers have limited effective weed management options, and most rely on in-season between-row cultivation and hand weeding, which are time consuming, are costly, and deteriorate soil quality. Studies were conducted at the Samuel G. Meigs Horticulture Research Farm, Lafayette, IN, and at the Southwest Purdue Agricultural Center, Vincennes, IN, in 2022 and 2023 to determine the effects of in-row plant spacing and cultivar selection on weed suppression and organic sweetpotato yield. The experiment was a split-split plot design, with in-row spacings of 20, 30, and 40 cm as the main plot factor, weeding frequency (critical weed-free period and weed-free) as the subplot factor, and sweetpotato cultivar ('Covington' and 'Monaco') as the sub-subplot factor. However, in 2022, we evaluated only in-row spacing and weeding frequency because of the poor establishment of 'Monaco'. In 2023, sweetpotato canopy at 5 wk after transplanting (WAP) decreased as in-row spacing increased from 20 to 40 cm, and sweetpotato canopy cover of 'Monaco' (62%) was greater than that of 'Covington' (44%). In-row spacing did not affect weed density at 4, 5, and 6 WAP. As in-row spacing increased from 20 to 40 cm, total sweetpotato yield pooled across both locations in 2023 decreased from 30,223 to 21,209 kg ha^{-1} for 'Covington' and from 24,370 to 20,848 kg ha^{-1} for 'Monaco'; however, jumbo yield increased for both cultivars. Findings from this study suggest that an in-row spacing of 20 cm may provide greater yield than the standard spacing of 30 cm for both 'Monaco' and 'Covington'.

Introduction

Sweetpotato, a tropical vine originating from Central and South America, is one of the major vegetable crops grown certified organic in the United States (Woodard et al. 2024). While predominantly cultivated in tropical and subtropical zones, it can be grown in temperate areas with a minimum of five frost-free months and day and night air temperatures ranging between <30 C and >16 C (Gajanayake et al. 2014; Ray and Tomlins 2010). Sweetpotato production in the United States is centered primarily in the southeastern region, with North Carolina leading the list of states in production (USDA-NASS 2020).

Organic sweetpotato production has experienced a notable rise in recent years within the United States (Crowder and Reganold 2015; Ponisio et al. 2015). In 2019, 401 organic sweetpotato farms harvested 3,695 ha, yielding approximately 85 million kg of sweetpotatoes, valued at US$77 million (USDA-NASS 2020). According to Nwosisi et al. (2021), organic sweetpotato production systems can result in 50% higher profits compared to conventional systems, despite lower yield. The reduced yield in organic systems is often linked to losses from weed competition, an issue that organic growers have identified as a top priority (SLM, unpublished data). Weeds compete for light, water, and nutrients (Basinger et al. 2019; Meyers et al. 2010; Meyers and Shankle 2015; Smith et al. 2020). The extent of sweetpotato yield loss can vary significantly due to factors such as cultivar, weed species, environmental conditions, and management strategy. Cooper et al. (2024) documented yield reduction ranging from 65% to 88% for three cultivars due to season-long weed interference. Meyers et al. (2010) reported a 62% decrease in marketable sweetpotato yield with a Palmer amaranth (*Amaranthus palmeri* S. Watson) density of 2 plants m^{-1} of crop row. Sweetpotato population could be explored as a weed control strategy to mitigate yield loss caused by weed interference.

In-row plant spacing or planting density can affect sweetpotato growth and storage root yield with variability dependent on cultivar and location (Anderson et al. 1945; Arancibia et al. 2014; Duque et al. 2022; Guertal and Kemble 1997; Peterson 1961; Schultheis et al. 1999). It can also influence the development of the crop canopy (Shrestha and Miles 2022). In North Carolina, the typical in-row spacing for sweetpotato ranges from 20 to 36 cm (Jennings et al. 2019). Recommendations for in-row spacing across various cultivars, irrespective of region, are typically within the range of 23 to 40 cm (Anderson et al. 1941; Rubatzky and Yamaguchi 1997).

Narrower plant spacing can delay storage root enlargement, while wider plant spacing can expedite enlargement (Kemble 2023). The desired storage root size for a grower is determined predominantly by market demand (Arancibia et al. 2014). The U.S. standards delineate sweetpotato storage root grades into distinct categories based on size and quality. For sweetpotato growers focusing on the fresh market, the goal is to maximize the yield of U.S. No. 1 (>4.4 to 8.9 cm diameter) roots. Conversely, growers targeting solely the processing market aim for increased total yield, resulting in a greater proportion of jumbo (>8.9 cm diameter) roots.

Even with efforts to understand the influence of in-row plant spacing on yield, a notable gap exists in research regarding how in-row spacing specifically affects weed suppression in sweetpotato production. Laurie et al. (2015) highlighted narrow plant spacing as among the most effective weed management strategies, alongside the use of inorganic mulching in sweetpotato production. Champion et al. (1998) found that weed biomass showed sensitivity to both wheat (*Triticum aestivum* L.) crop density and cultivar type. In dry bean (*Phaseolus vulgaris* L.), narrow row spacing led to more effective suppression of hairy nightshade (*Solanum sarrachoides* auct. non Sendtn.), contributing to a higher yield that was particularly noticeable in upright cultivars compared to viny cultivars (Blackshaw et al. 1999). Narrow row spacing in corn (*Zea mays* L.) contributes to weed suppression by allowing the crop to intercept more light (Dalley et al. 2006). This encourages faster crop growth rates and earlier canopy closure, which in turn shades out late-emerging weeds. A quicker canopy closure increases weed shading, enhances crop competitiveness, and ultimately curtails weed emergence and growth (Blackshaw et al. 1999; Dalley et al. 2006).

The impact of in-row spacing on weed suppression can vary based on the cultivar. Within sweetpotato cultivars, there exists a wide range of shoot morphological traits, such as internode length and leaf size, shape, and orientation. These traits, in part, contribute to two primary growth habits observed in sweetpotato cultivars: trailing, characterized by longer internodes, and bunch types, which feature shorter internodes. This diversity in growth habits and physical characteristics among cultivars can significantly influence how effectively in-row spacing suppresses weeds in sweetpotato fields.

Harrison and Jackson (2011) explored the impact of weed interference on the yield of two distinct sweetpotato cultivars: 'Carolina Bunch', with a semi-erect growth habit, and 'Beauregard', exhibiting a trailing growth habit. Their findings indicate that 'Carolina Bunch' exhibited greater tolerance to weed interference than 'Beauregard', as evidenced by percent yield reduction. However, the authors did not assess the combined effects of in-row spacing and cultivar on weed suppression. Investigating the combined effects of sweetpotato with differing canopy architectures in addition to in-row spacing may provide valuable insight into weed management strategies for organic sweetpotato production. This study aimed to explore how the varying growth habits exemplified by the trailing growth habit of 'Covington' and the semi-erect bunch-type growth habit of 'Monaco' might influence weed interference and yield in sweetpotato production under different in-row spacing conditions.

Materials and Methods

Locations and Field Preparation

Field experiments were conducted in certified organic fields at the Samuel G. Meigs Horticulture Research Farm, Lafayette, IN (40.28°N, 86.88°W), and at the Southwest Purdue Agricultural Center, Vincennes, IN (38.74°N, 87.48°W), in 2022 and 2023. At Lafayette, the soil type was a mixture of Starks (fine-silty, mixed, superactive, mesic Aeric Endoaqualfs) and Fincastle (fine-silty, mixed, superactive, mesic Aeric Epiaqualfs) silt loam with 1.6% organic matter and pH 6.4. At Vincennes, the soil was a Bloomfield loamy fine sand (sandy, mixed, mesic Lamellic Hapludalfs) with 1.0% organic matter and pH 6.1. At the Lafayette location, the field was mowed using a Bush Hog 2212 (Bush Hog, Selma, AL, USA) to facilitate the removal of cover crops and winter annual weeds, then tilled with three passes using a field cultivator (Farmall 200, International Harvester Company, Chicago, IL, USA) attached to a John Deere 6410 tractor (John Deere, Moline, IL, USA). Fertilizer at 1,345 kg ha^{-1} of 5-4-5 (Revita Pro™, Ohio Earth Food, Hartville, OH, USA) and at 224 kg ha^{-1} of 0-0-50 (sulfate of potash, Ohio Earth Food) was incorporated into the soil prior to bed formation. At the Vincennes location, the field was tilled once with a rotary tiller (Land Pride RTR2570, Great Plains Manufacturing, Salinas, KS, USA) attached to a Ford 8360 (Ford–New Holland, Dearborn, MI, USA) tractor and disked three times with a Ford Flex hitch disk (Ford–New Holland) attached to a John Deere 2510 tractor to incorporate fall-planted cover crops and winter annual weeds. Owing to the sandy soil texture and the likelihood of nutrient loss from infiltration, fertilizer application at Vincennes in 2022 and 2023 was split, with 50% of the total applied before bed formation and the remainder applied 8 wk after transplanting (WAP). Raised beds were formed using a Buckeye 1512-ND bedder (Buckeye Tractor Co., Columbus Grove, OH, USA) attached to a New Holland 1510 tractor (New Holland Agriculture, New Holland, PA, USA) 1 d before planting (DBP) at Vincennes and a Rain-Flo 2550 (Rain-Flo Irrigation, East Earl, PA, USA) attached to a John Deere 6410 tractor 3 DBP at Lafayette. A single drip tape was laid near the center of each row at bed formation.

Treatments and Experimental Design

In both years and at both locations, the experimental design was a randomized complete block with four replicates. In 2022, the treatments consisted of a split-split-plot arrangement in which in-row spacing (20, 30, or 40 cm) was the main plot factor. The subplot factor was weeding frequency with two levels: weekly during the 2 to 6 WAP critical weed-free period (CP) or weed-free (WF) weekly over the entire 16-wk growing season. The sub-subplot factor was sweetpotato cultivar ('Covington' or 'Monaco'). In 2022, sweetpotato yield did not differ by weeding frequency; therefore all plots in 2023 were only weeded 2 to 6 WAP, resulting in a split-plot arrangement with the main plot factor of in-row spacing and the subplot factor of cultivar. The 2 to 6 WAP weeding frequency was chosen because it represents the CP reported for 'Beauregard' sweetpotato by Seem et al. (2003). 'Covington', an orange-fleshed sweetpotato developed by researchers at North Carolina State University in 1998, is the most prevalent cultivar grown in North Carolina (Schultheis 2023). It has a trailing growth habit, characterized by thick stems and limited branching, yet it forms a dense canopy (Yencho et al. 2008). 'Monaco', also an orange-fleshed cultivar, displays a semi-erect bunch-type growth habit and is reported to be resistant to some insects (Wadl et al. 2023).

Transplanting and Plot Maintenance

Nonrooted, organic sweetpotato vine tip cuttings (slips) 25 to 30 cm long ('Covington', Jones Family Farms, Bailey, NC, USA [2022, 2023]; 'Monaco', North Carolina State University, Raleigh, NC, USA [2023]) were hand transplanted on June 8, 2022, and June 7, 2023, at Lafayette and on June 9, 2022, and June 8, 2023, at Vincennes into raised beds 2 m apart. Plots were 6 m long and 0.8 m wide, resulting in 30, 20, and 15 plants plot^{-1} for in-row spacings of 20, 30, and 40 cm, respectively. Row middles for all plots were weeded only twice using a "G" tractor with Danish-tine cultivator at Vincennes and a Farmall 200 cultivator at Lafayette for the first 6 WAP. Weed density and size were used to determine cultivation for this 6-wk period. This was supplemented by hand weeding the row middles until sweetpotato vines completely covered them. Plots were irrigated through the drip tape as needed to supplement rainfall during the growing season.

Data Collection and Analysis

Sweetpotato stand counts were recorded at 2 WAP in 2022 and 3 WAP in 2023 to determine plant establishment. Weed density and sweetpotato canopy cover were recorded using a 0.09-m^2 quadrat in each subplot at 4, 5, and 6 WAP. Weed count and height data were collected before removing weeds from plots at 3 and 6 WAP. Sweetpotato leaf number and vine length were recorded from two plants randomly selected in each subplot at 3, 4, 5, and 7 WAP. Open leaves were counted from the entire plant, and the longest vine from each selected plant was recorded. At 15 WAP, an estimate of sweetpotato canopy cover was recorded using the entire plot. Sweetpotato canopy cover was visually recorded from the top of the raised beds as an estimate of the total ground surface area using a scale of 0% (no cover) to 100% (complete cover). For both 2022 and 2023, at 111 d after transplanting (DAP), aboveground biomass in all plots was rotary mowed using a Bush Hog 2212 attached to a John Deere 6410 tractor at Lafayette and a Bush Hog 287 attached to a Ford 7600 at Vincennes to remove foliage and facilitate smooth operation of equipment for harvest. Sweetpotato roots were harvested at 112 DAP with a single-row chain digger (Willsie Equipment Sales, Thedford, ON, Canada). Storage roots were graded and weighed as jumbo (>8.9 cm diameter), U.S. No. 1 (>4.4 to 8.9 cm diameter), canner (>2.5 to 4.4 cm diameter), or cull (misshapen roots) (USDA-AMS 2005). The summation of jumbo, U.S. No. 1, canner, and cull is presented as total yield.

Data were subjected to analysis using R software (RStudio®; R Core Team 2019). In 2022, insufficient (60%) establishment of the 'Monaco' cultivar prevented us from achieving the desired in-row plant spacing for our plots at both sites. Consequently, our analysis for 2022 was only for the 'Covington' variety. Data for both locations were subjected to analysis of variance (ANOVA) using the split-plot model to test the main effects (in-row spacing and weeding frequency) and their interaction. In-row plant spacing and weeding frequency were treated as whole-plot factor and subplot factor, respectively, and location and replicate as the block factors, whereas in 2023, in-row plant spacing and sweetpotato cultivar were treated as whole-plot factor and subplot factor, respectively, and location and replicate as the block factors. When a significant Treatment × Location interaction ($P \leq 0.05$) existed for a response variable, data were analyzed and presented separately by location within each year. Means were separated using Tukey's honestly significant difference (HSD) test at $P \leq 0.05$. A Pearson product moment correlation test of linear fit was used to check for the relationship between the continuous variables of sweetpotato canopy at 5 WAP and total yield and in-row spacing and total yield using R software.

Results and Discussion

Plant Establishment and Growth

Plant stand, leaf number, and vine length data were combined across locations in 2022 and 2023 because there was no significant Treatment × Location interaction. For both years, in-row plant spacing had no significant effect on plant stand, leaf number, or vine length. Cultivar had a significant effect on the average plant stand. In 2022, the average plant stand was 99% for 'Covington' at 2 WAP. In 2023, average plant stand differed minimally between 'Monaco' (98%) and 'Covington' (95%) at 3 WAP (data not shown). Cultivar had a significant effect on leaf number in 2023. At 3 and 4 WAP, leaf number was greater for 'Monaco' (11 and 17 leaves plant^{-1}, respectively) than for 'Covington' (9 and 14 leaves plant^{-1}, respectively) (data not shown). Cultivar also had a significant effect on vine length in 2023. At 5 and 7 WAP, sweetpotato longest vine length was greater for 'Covington' (38 and 60 cm, respectively) than for 'Monaco' (24 and 36 cm, respectively) (data not shown). These data suggest that 'Covington' allocated resources primarily toward increasing vine length, whereas 'Monaco' allocated a larger portion of its resources toward leaf development.

Weed Composition and Density

Weed species and density varied for the two locations. In 2022, weeds at Lafayette were barnyardgrass [*Echinochloa crus-galli* (L.) P. Beauv.], redroot pigweed (*Amaranthus retroflexus* L.), common purslane (*Portulaca oleracea* L.), yellow nutsedge (*Cyperus esculentus* L.), and velvetleaf (*Abutilon theophrasti* Medik.). In 2023, weeds were barnyardgrass, giant foxtail (*Setaria faberi* Herrm.), goosegrass [*Eleusine indica* (L.) Gaertn.], large crabgrass [*Digitaria sanguinalis* (L.) Scop.], and Canada thistle [*Cirsium arvense* (L.) Scop.]. In 2022, weeds at Vincennes were carpetweed (*Mollugo verticillata* L.), waterhemp (*Amaranthus rudis* Sauer), common lambsquarters (*Chenopodium album* L.), and large crabgrass. However, in 2023, more waterhemp and less carpetweed were observed in addition to common ragweed (*Ambrosia artemisiifolia* L.) and common lambsquarters.

Weed density data at 3 and 6 WAP were pooled across locations because there was no significant Treatment × Location interaction in 2022 or 2023. In-row plant spacing (2022, 2023), weeding frequency (2022), and cultivar (2023) had no significant effect on weed density at 3 and 6 WAP. This differs from the findings of Blackshaw et al. (1999), who reported that higher dry bean plant density led to increased hairy nightshade suppression. Additionally, Workayehu et al. (2011) found a negative correlation between sweetpotato plant density and weed infestation, indicating that weed density tends to be lower at higher sweetpotato plant densities. High plant density can lead to the development of a

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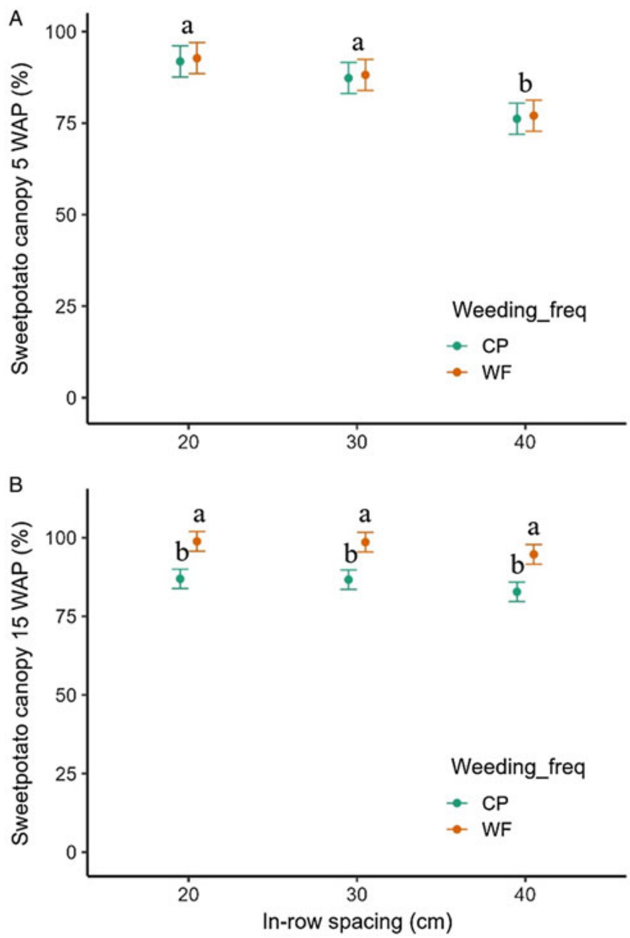

Figure 1. Effect of in-row plant spacing and weeding frequency on visual estimation of sweetpotato canopy cover at (A) 5 WAP and (B) 15 WAP in 2022 pooled across Lafayette and Vincennes, IN. Points and bars represent observed mean and standard error, respectively. Letters represent differences with Tukey's HSD ($P < 0.05$) by (A) in-row spacing and (B) weeding frequency. Abbreviations: CP = critical period (2 to 6 WAP); WF = weed-free.

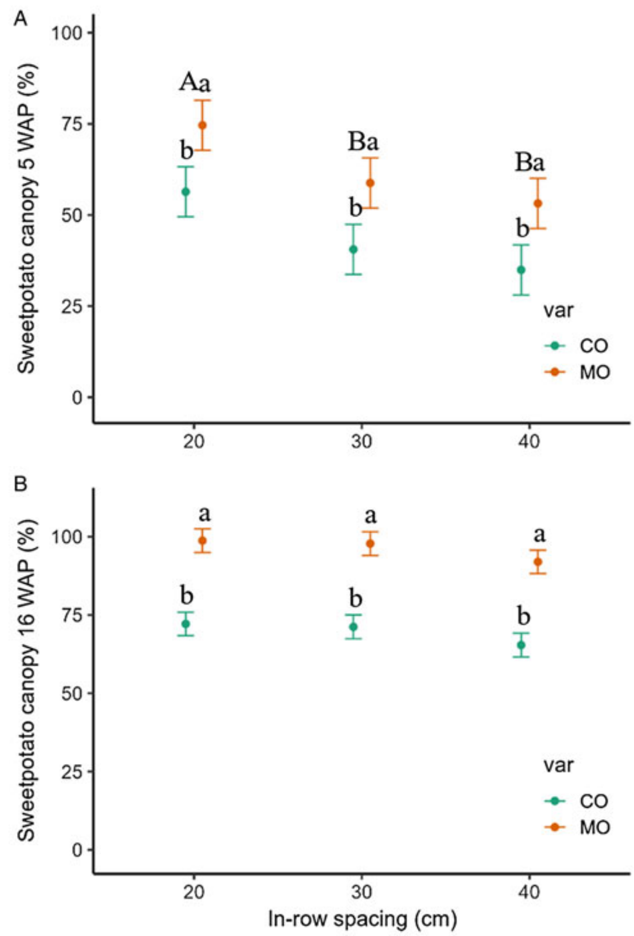

Figure 2. Effect of in-row plant spacing and weeding frequency on visual estimation of sweetpotato canopy cover at (A) 5 WAP and (B) 16 WAP pooled across Lafayette and Vincennes, IN, in 2023. Points and bars represent observed mean and standard error, respectively. Letters represent differences with Tukey's HSD ($P < 0.05$) by in-row spacing (capital letters) and sweetpotato cultivar (lowercase letters). Abbreviations: CO = 'Covington'; MO = 'Monaco'; var = variety.

canopy that shades the soil, thereby hindering the germination and establishment of weeds. Moreover, the increased competition for resources, such as light, nutrients, and water, may further contribute to a reduced weed density.

Sweetpotato Canopy

Data were combined across locations because no significant Treatment × Location interaction was observed for either year. At 5 WAP in 2022, sweetpotato canopy cover did not differ due to weeding frequency, but it did differ by in-row spacing. Pooled across weeding frequency, visual sweetpotato canopy cover was 92%, 87%, and 76% for 20-, 30-, and 40-cm plant spacing, respectively (Figure 1 A). In contrast, at 15 WAP in 2022, in-row spacing had no effect on sweetpotato canopy cover; however, weeding frequency did. Pooled across in-row spacings, sweetpotato canopy cover was 85% for the CP and 97% for the WF (Figure 1 B).

In 2023, both in-row plant spacing and cultivar had a significant effect on canopy cover at 5 WAP. Visual sweetpotato canopy cover was 54%, 46%, and 32% for 'Covington' and 77%, 54%, and 56% for 'Monaco' at 20, 30, and 40 cm, respectively (Figure 2 A). However, at 16 WAP, only cultivar had a significant effect on sweetpotato canopy. Pooled across in-row spacing, sweetpotato canopy cover was 70% for 'Covington' and 96% for 'Monaco' (Figure 2 B). These results were similar to findings from Shrestha and Miles (2022), who reported greater 'Covington' sweetpotato canopy cover for 20-cm spacing than for 30- and 38-cm spacing. They attributed the greater canopy cover of decreased in-row spacing to the intermingling of vines from adjacent plants. In this study, 'Monaco' demonstrated greater canopy cover than 'Covington'. The semi-erect bunch-type growth habit of 'Monaco' contributed to more concentrated shoot growth. The findings may suggest that the physical characteristics of 'Monaco' could prove valuable in implementing an effective weed management strategy.

Sweetpotato Yield

In 2022 and 2023, yield data were pooled across locations because there was no significant Treatment × Location interaction. In-row spacing had a significant effect on U.S. No. 1, jumbo, canner, and total yield, but weeding frequency had no significant effect in 2022 (Figure 3). As in-row spacing increased from 20 to 40 cm, U.S. No. 1, canner, and total yields decreased, while jumbo yield increased. Specifically, at 20-cm spacing, both canner and jumbo yields were 4,390 kg ha^{-1}, U.S. No. 1 yield was 22,190 kg ha^{-1}, and the total yield across all grades was 30,970 kg ha^{-1}. Conversely, at 30-cm

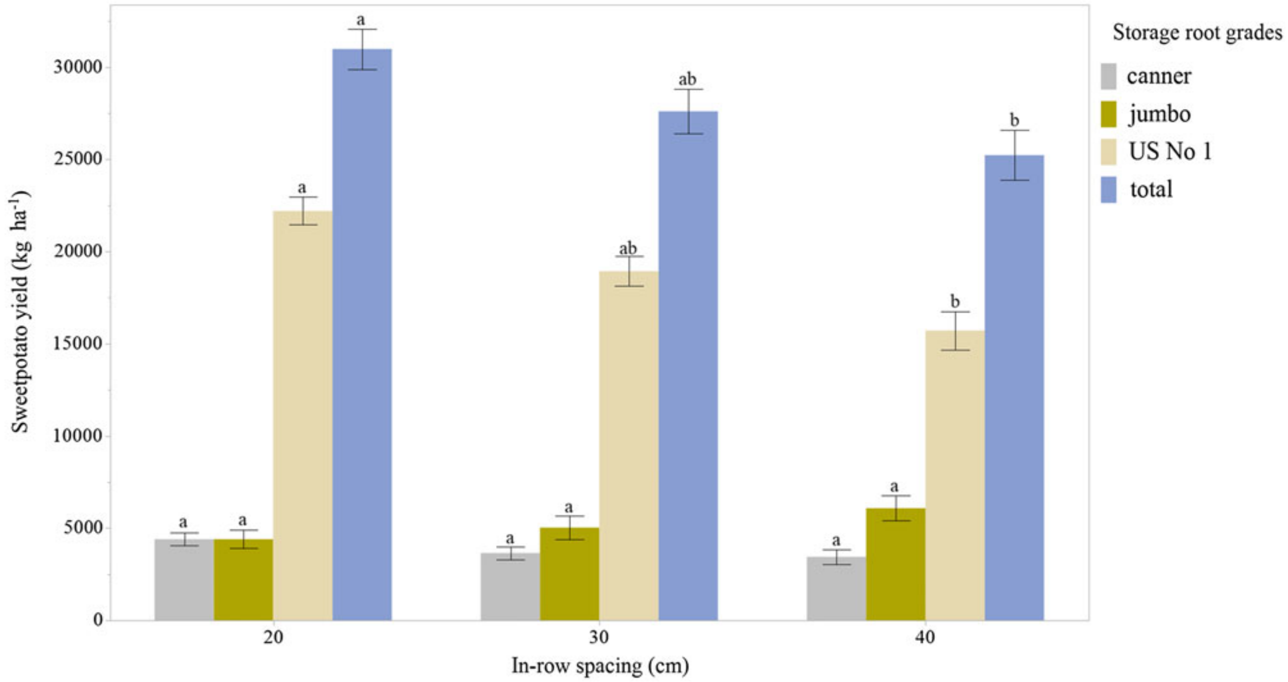

Figure 3. Effect of in-row plant spacing on 'Covington' canner, jumbo, U.S. No. 1, and total yields in 2022 pooled across weeding frequency and location. Bars and error intervals represent observed mean and standard error, respectively. Letters represent differences with Tukey's HSD (P < 0.05) by in-row spacing within each grade.

spacing, yields were 3,640 kg ha^{-1} for canner, 5,020 kg ha^{-1} for jumbo, 18,930 kg ha^{-1} for U.S. No. 1, and 27,590 kg ha^{-1} for total grades. Finally, at 40-cm spacing, yield was 3,430 kg ha^{-1}, 6,080 kg ha^{-1}, 15,700 kg ha^{-1}, and 25,210 kg ha^{-1} for canner, jumbo, U.S. No. 1, and total grades, respectively.

In 2023, as in-row spacing increased from 20 to 40 cm, U.S. No. 1, canner, and total yields decreased, while jumbo yield increased. The U.S. No. 1 yield for 'Monaco' was 18,030, 16,750, and 13,920 kg ha^{-1} at 20-, 30-, and 40-cm spacing, respectively. Similarly, for 'Covington', the U.S. No. 1 yield was 18,630, 14,850, and 10,380 kg ha^{-1} at 20-, 30-, and 40-cm spacing, respectively (Figure 4 A). Total yield was 24,370 kg ha^{-1}, 24,700 kg ha^{-1}, and 20,850 kg ha^{-1} for 'Monaco' and 30,220 kg ha^{-1}, 25,460 kg ha^{-1}, and 21,210 kg ha^{-1} for 'Covington' at 20-, 30-, and 40-cm spacing, respectively (Figure 4 B). There was a significant effect of both in-row plant spacing and cultivar on jumbo and canner yields (Figures 4 C and D). Pooled across cultivars, jumbo yield increased as in-row spacing increased. Jumbo yield was 5,440 kg ha^{-1}, 6,350 kg ha^{-1}, and 6,600 kg ha^{-1} for 20-, 30-, and 40-cm spacing, respectively. However, jumbo yield was 70% greater for 'Covington' (7,730 kg ha^{-1}) than for 'Monaco' (4,530 kg ha^{-1}) when data were pooled across in-row spacings. For both cultivars, canner yield decreased as in-row spacing increased. Canner yield was 3,490 kg ha^{-1}, 2,490 kg ha^{-1}, and 1,660 kg ha^{-1} for 'Monaco' and 3,570 kg ha^{-1}, 3,360 kg ha^{-1}, and 2,910 kg ha^{-1} for 'Covington' at 20-, 30-, and 40-cm spacing, respectively. U.S. No. 1 yield for 'Monaco' was greater than it was for 'Covington'. However, 'Covington' had a greater yield for both jumbo and canner grades, resulting in a greater total yield than 'Monaco'.

Harrison and Jackson (2011) reported that 'Carolina Bunch' yield was reduced less in the presence of weeds than 'Beauregard'. This was attributed to its robust growth habit and the formation of a dense canopy, distinguishing 'Carolina Bunch' from the more prostrate growth habit of 'Beauregard'. Schultheis et al. (1999) documented a notable increase in U.S. No. 1, canner, and total marketable 'Beauregard' sweetpotato yield as in-row plant spacing decreased. Their findings indicate that increased yield at higher plant densities was particularly evident for delayed harvests at 110 DAP or more. Additionally, they observed an increase in jumbo yield with wider in-row plant spacing, attributing this phenomenon to reduced intraspecific competition among plants. In the current study, we saw a similar pattern. A reduction in U.S. No. 1, canner, and total yield was observed, as was an increase in jumbo yield, as in-row spacing increased. Notably, in 2023, 'Monaco' demonstrated greater U.S. No. 1 yield compared to 'Covington' when both were harvested at 112 DAP. Conversely, 'Covington' demonstrated greater jumbo yield. Considering the optimal harvest dates outlined in previous literature, where 'Covington' can be harvested between 90 and 120 DAP and 'Monaco' between 110 and 140 DAP, our harvest date favored the formation of jumbo roots for 'Covington'. This observation aligns with the assertion of Somda et al. (1991) that the shape of storage roots and root length are established by ~8 WAP, while width continues to increase throughout the growing season. With 'Covington' having a shorter growth period, many of the U.S. No. 1 roots increased in size, leading to the development of more jumbo roots compared to 'Monaco'.

Correlation Analysis

A Pearson product moment correlation test of linear fit was used to check for relationships between the continuous variables of sweetpotato canopy at 5 WAP and total yield and in-row spacing and total yield. Pooled across locations and cultivars in 2023, a significant ($P < 0.001$) positive correlation ($R^2 = 0.60$) was observed between visual sweetpotato canopy cover at 5 WAP and total yield (Figure 5). Additionally, there was a significant ($P < 0.05$) negative correlation ($R^2 = -0.31$) between in-row plant

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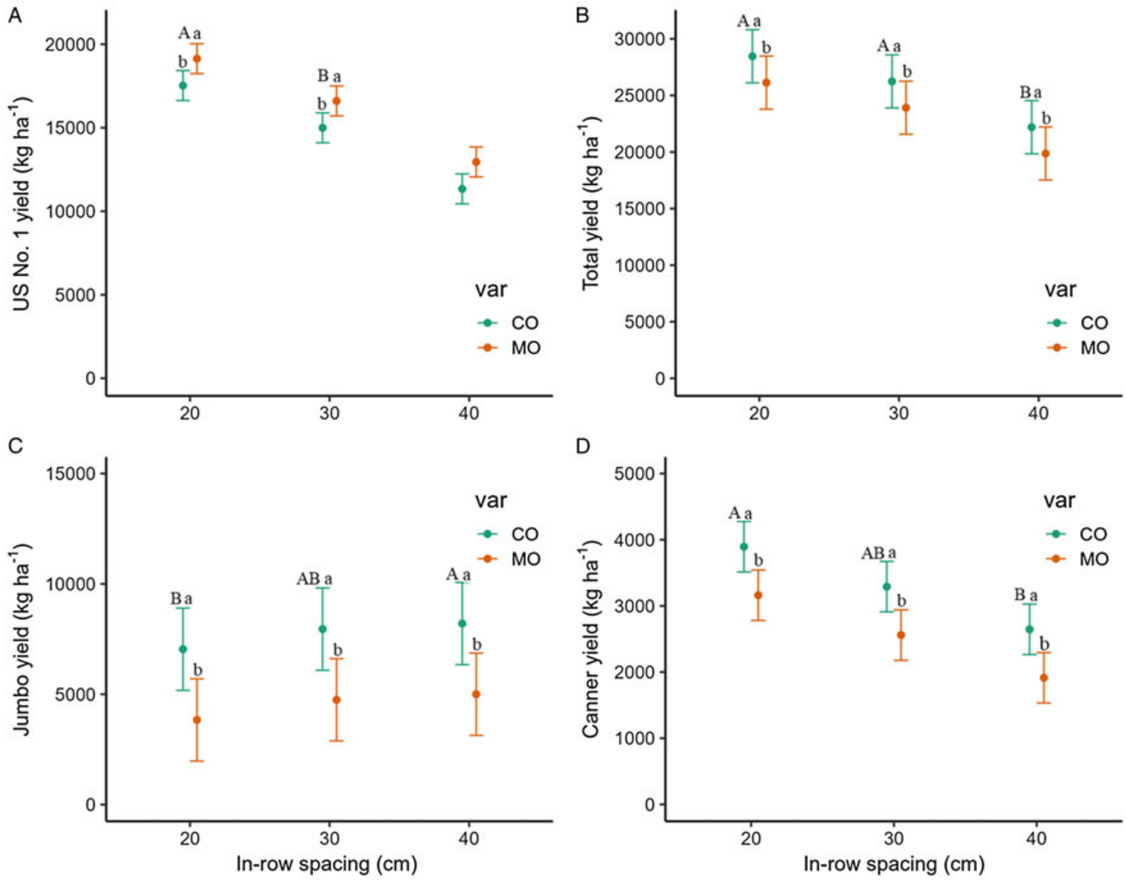

Figure 4. Effect of in-row plant spacing and cultivar on (A) U.S. No. 1, (B) total, (C) jumbo, and (D) canner yields in 2023 pooled across Lafayette and Vincennes, IN. Points and bars represent observed mean and standard error, respectively. Letters represent differences with Tukey's HSD ($P < 0.05$) by in-row spacing (capital letters) and sweetpotato cultivar (lowercase letters). Abbreviations: CO = 'Covington'; MO = 'Monaco'; var = variety.

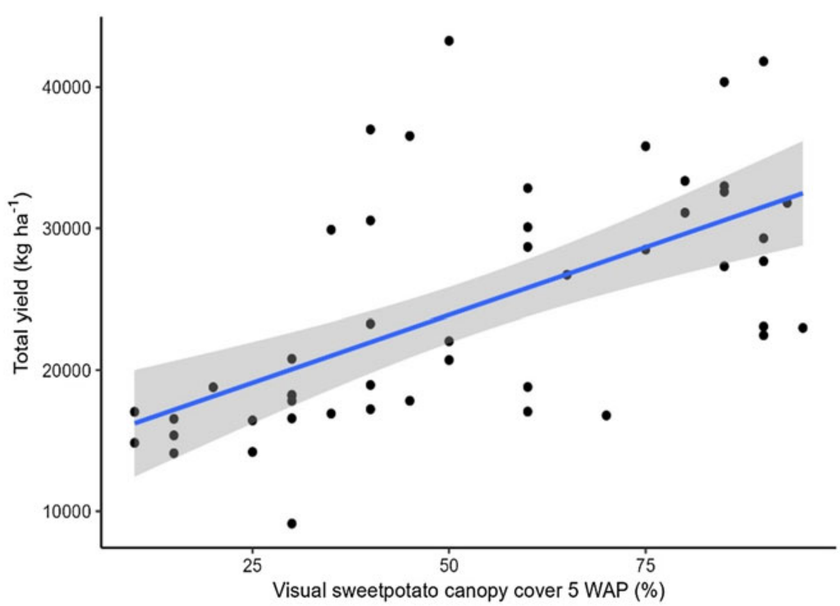

Figure 5. Total sweetpotato yield as influenced by visual sweetpotato canopy cover 5 WAP pooled across Lafayette and Vincennes, IN, in 2023. Pearson's product-moment correlation test $t(46) = 5.14$, P-value $= 5.46e^{-6}$ with a 95% CI and correlation of 0.60.

spacing and total yield. Thus, as sweetpotato canopy at 5 WAP increased, total sweetpotato storage root increased. However, as in-row plant spacing increased, total yield decreased. This result suggests that regardless of cultivar, early canopy could be a determining factor for yield prediction in sweetpotato production.

A primary objective of this study was to investigate the impact of in-row plant spacing on weed interference and sweetpotato yield, considering the potential influence of cultivar growth habits. Anticipating that reduced in-row spacing would contribute to the suppression of weeds and enhance yields, our hypothesis proposed that the semi-erect growth cultivar ('Monaco') would outperform the longer-internode, trailing growth cultivar ('Covington') in terms of yield and weed suppression. Furthermore, in 2022, the effects of weeding frequency on sweetpotato yield were not significant. Weeding during the initial 2 to 6 WAP was sufficient for the crop to achieve yields comparable to those obtained through continuous weeding throughout the season. Similarly, Seem et al. (2003) reported that irrespective of planting dates, the critical WF period for 'Beauregard' was 2 to 6 WAP. Intriguingly, our study revealed no impact of in-row plant spacing or cultivar on weed interference or suppression. Weed densities remained similar across various plant spacing and cultivar conditions.

Practical Implication

Our findings reveal that a 20-cm in-row plant spacing consistently resulted in greater yields of U.S. No. 1 roots compared to 30- and 40-cm spacings. Interestingly, there were no differences in total yield between the 20- and 30-cm spacings, but the 20-cm plant spacing exhibited a greater total yield than the 40-cm plant spacing. This aligns with numerous studies investigating in-row plant spacing effects on sweetpotato production for various cultivars, consistently reporting similar trends. Existing research has consistently shown that in-row spacings ranging from 23 to 30 cm contribute to a reduction in the number of jumbo roots while maximizing the production of desirable U.S. No. 1 roots (Anderson et al. 1941; Rubatzky and Yamaguchi 1997; Schultheis et al. 1999). This finding holds significance for the profitability of sweetpotato production, especially for small-scale farmers. The reduction in in-row plant spacing emerges as a potential tool for enhancing productivity in organic systems, in which cultivar may play a pivotal role. However, to make informed decisions regarding in-row plant spacing, further research is warranted. Evaluation of factors such as planting and harvesting dates, as well as a comprehensive analysis of costs and return on investment, will be crucial in optimizing sweetpotato production practices. This holistic approach will contribute to a more nuanced understanding of the interplay between cultivation strategies, cultivar characteristics, and economic considerations in organic sweetpotato farming.

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