Weed Science

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Evaluation of critical weed-free period for three sweetpotato (*Ipomoea batatas*) cultivars

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Research Article

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Abstract

Sweetpotato [*Ipomoea batatas* (L.) Lam.] is a staple crop that provides nutritional benefits to humans globally, but it is subject to yield loss when competing with weeds, especially during the early stage of establishment. Yield loss can vary widely based on the cultivar, production environment, weed species, and management techniques. To address this challenge, we conducted field research at the Samuel G. Meigs Horticulture Research Farm, Lafayette, IN, and at the Southwest Purdue Agricultural Center, Vincennes, IN, in 2022 to determine the effect of sweetpotato cultivar on the critical weed-free period. The experiment was a split-plot design, with weed-free interval treatments as the main plot factor and cultivar as the subplot factor. The three cultivars used were 'Covington', 'Monaco', and 'Murasaki'. Weeds were removed by hand and allowed to establish and compete with the crop beginning at 0, 14, 21, 28, 35, or 42 d after transplanting (DAP). As the weed-free interval increased from 0 to 42 DAP, predicted total yield increased from 19 kg ha^{-1} to 20,540 kg ha^{-1} for Covington, 3 kg ha^{-1} to 11,407 kg ha^{-1} for Monaco, and 125 kg ha^{-1} to 13,460 kg ha^{-1} for Murasaki at the Lafayette location. At Vincennes, as the weed-free interval increased from 0 to 42 DAP, predicted total yield increased from 14,664 kg ha^{-1} to 33,905 kg ha^{-1} for Covington, 4,817 kg ha^{-1} to 18,059 kg ha^{-1} for Monaco, and 12,735 kg ha^{-1} to 21,105 kg ha^{-1} for Murasaki. A threshold of ≤10% total yield reduction was achieved by maintaining sweetpotatoes weed-free 24 DAP for Covington, 20 DAP for Murasaki, and 33 DAP for Monaco.

Introduction

Sweetpotato [*Ipomoea batatas* (L.) Lam.] is a tropical Central and South American vine and member of the botanical family *Convolvulaceae.* It is primarily grown in tropical and subtropical regions, but can also thrive in temperate regions with at least five frost-free months and day and night air temperatures of ≤30 C and ≥16 C, respectively (Gajanayake et al. 2014; Ray and Tomlins 2010; Villordon et al. 2009). Sweetpotatoes are cultivated worldwide on 7.4 million ha with an annual production of 89 billion kg, averaging 12,000 kg ha^{-1} (FAOSTAT 2020). Approximately 95% of the global production is in regions of Asia (63%) and Africa (32%). In 2020, the United States ranked 10th in sweetpotato production globally, representing 1.7% of global production, with the greatest production in the southeastern United States (Nwosisi et al. 2021).

Sweetpotato is used for human consumption, animal feed, and processing into nutraceuticals. Currently, scientists are exploring the potential of sweetpotato products to provide nutritional and health benefits (Dos Santos et al. 2017). Sweetpotato storage roots and leaves are sources of vitamins B, C, and E; calcium; zinc; polyphenols; carotenoids; and proteins (Bovell-Benjamin 2007; Islam 2006). Sweetpotato roots are low in calories, have anti-diabetic effects, and may alleviate blood sugar levels and reduce insulin resistance (Ludvik et al. 2004; Mohanraj and Sivasankar 2014). Sweetpotato leaves have high polyphenol and xanthophyll content (Grace et al. 2014). Phenolics have high antioxidant activity, and xanthophylls form lutein concentration, which is capable of mitigating eye diseases like age-related macular degeneration and cataracts (Bovell-Benjamin 2007; Ishiguro and Yoshimoto 2005; Padda and Picha 2008).

Organic production of sweetpotatoes has been on the increase in recent years in the United States (Crowder and Reganold 2015; Ponisio et al. 2015). According to a report from the U.S. Department of Agriculture (USDA-NASS 2020), U.S. organic sweetpotato increased from 1,760 to 3,904 ha between 2011 to 2016. In 2015, the USDA–National Agriculture Statistics Service reported 229 organic sweetpotato farms totaling 2,831 ha and 105 million kg of storage roots (USDA-NASS 2020). Organic sweetpotato production is valued at approximately US$77 million annually, making it the fourth highest commodity sold of all organic vegetables (USDA-NASS 2020).

Despite the advantages of sweetpotato, there is concern about the productivity of this crop, particularly given the limited number of options available for weed control. Weed management in sweetpotato production relies on herbicides, preplant tillage, in-season between-row cultivation, and hand weeding (Lewthwaite and Triggs 2000; Nwosisi et al. 2019). Multiple cultivations and hand weeding are time-consuming and costly (Chaudhari et al. 2020). While herbicides can effectively control weeds in sweetpotato production, their usage is generally restricted to conventional farms, except for a few products approved by the Organic Materials Review Institute for organic farming.

Weeds can cause significant sweetpotato yield loss by competing for light, water, and nutrients (Basinger et al. 2019; Meyers et al. 2010; Meyers and Shankle 2015; Moody and Ezumah 1974; Seem et al. 2003; Smith et al. 2020). Yield loss can vary due to differing effects of cultivars, environment, weed species, and management techniques. Moody and Ezumah (1974) reported yield losses ranging from 22% in Hawaii to as high as 91% in Nigeria. Basinger et al. (2019) reported a 79% yield loss of sweetpotato due to Palmer amaranth (*Amaranthus palmeri* S. Watson) interference in North Carolina.

Acceptable yield loss (AYL) tolerable by a grower from weed interference is typically 2% to 5% (Knezevic et al. 2002). Controlling weeds during the critical period for weed control (CPWC) allows for yield equal to, or greater than, the AYL threshold. The CPWC can be determined by measuring two crop–weed competition components: the critical weed-free period (CWFP) and the critical timing of weed removal (CTWR). CWFP is defined as the minimum length of time after planting during which a crop must be kept free of weeds to prevent yield or quality reductions due to weed interference (Weaver 1984). The CTWR is the maximum length of time a crop can tolerate early-season weed competition before suffering irreversible yield reduction (Knezevic et al. 2002).

The sweetpotato CPWC has been evaluated in only a few studies under conditions of naturally occurring weeds, and the results have varied. In a trial in India, Nedunzhiyan et al. (1998) found that the CPWC is between 30 and 45 d after transplanting (DAP) sweetpotato. Seem et al. (2003) reported that 'Beauregard' sweetpotato had a CPWC of 2 to 6 wk after transplanting (WAP) in North Carolina and that plots kept weed-free 4 WAP or more had the same yield as the weed-free control. Levett (1992) reported that the CPWC in sweetpotato is from 7 to 56 DAP in the tropics and that 14 to 21 DAP was the most vulnerable period during which weed interference can lead to significant yield loss.

Variation of CWFP depends on the weed species composition in the field, but can also differ by cultivar. Among sweetpotato cultivars, there is great diversity in shoot morphological traits, including internode length and leaf size, shape, and orientation. Two primary growth habits of sweetpotato cultivars are trailing (longer internodes) and bunch types (shorter internodes). There is limited published research related to sweetpotato canopy architecture and weed tolerance or suppression. Harrison and Jackson (2011) compared the effect of weed interference on yield of two sweetpotato cultivars: 'Carolina Bunch' (semi-erect growth habit) and Beauregard (trailing growth habit). Results from the study suggested that Carolina Bunch tolerated weed interference better than Beauregard based on percent yield reduction. La Bonte et al. (1999) investigated the effect of weed interference on 11 sweetpotato clones. Based on percent yield reduction relative to a weed-free control, five clones were reported to be weed tolerant, and three of these five clones were identified to be semi-erect bunch- or medium-internode type. However, due to the time of the study, more contemporary cultivars were not evaluated, including 'Covington', 'Murasaki', and 'Monaco'.

Covington is the most common sweetpotato cultivar grown in North Carolina (Schultheis unpublished data). This orange-fleshed and smooth-skinned cultivar was developed by researchers at North Carolina State University (NCSU) in 1998 (Yencho et al. 2008). It has a trailing growth habit, thick stems, and few branches but produces a dense canopy. Murasaki, a purple-skinned, cream-fleshed cultivar, has a growth habit similar to that of Covington but with more branches and greater canopy biomass (La Bonte et al. 2008). Murasaki was selected in this study for its distinctive cream-colored flesh and higher dry matter content, which could be desirable for some organic sweetpotato consumers. Monaco, an orange-fleshed cultivar, has a semi-erect bunch-type growth habit and is reported to be insect resistant (Wadl et al. 2023). One of the major reasons to select this cultivar is that it has a shorter vine that should allow for later-season row middle cultivation compared with longer internode cultivars.

Cultivar responses to weed interference can play an important role in decision making for organic sweetpotato farmers, and those responses can vary depending on growing conditions (Wadl et al. 2022). Moreover, for organic growers, early weeding before the sweetpotato canopy forms is essential due to restrictions on mechanical cultivation, which may potentially harm the crop. Therefore, the objective of this study was to estimate the CWFP under field conditions for Covington, Murasaki, and Monaco in the Midwest.

Materials and Methods

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. At Lafayette, the soil was a mixture of Starks (fine-silty, mixed, superactive, mesic Aeric Endoaqualfs) and Fincastle (fine-silty, mixed, superactive, mesic Aeric Epiaqualfs) silt loam (fine-silty, mixed, superactive, mesic Aeric Endoaqualfs-Epiaqualfs) with 1.6% organic matter (OM) and pH 6.4. At Vincennes, the soil was a Bloomfield loamy fine sand (sandy, mixed, mesic Lamellic Hapludalfs) with 1.0% OM and pH 6.1. The experiment was designed as a randomized complete block with a split-plot arrangement of treatments and four replications. Weed-free interval was the main plot factor and sweetpotato cultivar was the subplot factor. Three sweetpotato cultivars were used, two with a trailing growth habit (Covington and Murasaki) and one with a bunch-type growth habit (Monaco). Plots were hand weeded weekly for 0 (weedy check), 14, 21, 28, 35, or 42 DAP, and an all season weed-free treatment served as a weed-free control. Naturally occurring weed populations were used in both trials.

To prepare the site at Lafayette, standing vegetation was mowed using a rotary mower (Bush Hog 2212, Bush Hog, Selma, AL), then the field was subjected to three passes of a field cultivator (Farmall 200, International Harvester Company, Chicago, IL, USA), consisting of three rows of sweeps followed by a rolling basket, and attached to a John Deere (Moline, IL, USA) 6410 tractor. Fertilizer (1,350 kg ha^{-1} of 5-4-5; Revita Pro^{TM}, Ohio Earth Food, Hartville, OH; and 220 kg ha^{-1} of 0-0-50; sulfate of potash, Ohio Earth Food) was incorporated into the soil before bed formation. At Vincennes, site preparation consisted of a single pass of a rotary tiller (Land Pride RTR2570, Great Plains Manufacturing, Salinas, KS) attached to a Ford (Ford-New Holland, Dearborn, MI, USA) 8360 tractor followed by three passes of a disk (Ford Flexo-Hitch disk) attached to a John Deere 2510 tractor. The same amount of fertilizer was used as at the Lafayette location. However, due to the sandy soil texture and the likelihood of nutrient loss from infiltration, fertilizer applications at Vincennes were split, with 50% of the total applied before bed formation and the remainder applied 8 WAP.

Organic sweetpotato slips (25- to 30-cm long; Jones Family Farms, Bailey, NC) were hand transplanted on June 8, 2022, at Lafayette and June 9, 2022 at Vincennes into raised-bed plots 2 m apart with an in-row spacing of 30 cm. Each raised bed contained a single drip tape to supplement rainfall during the growing season. Raised beds for each subplot were 6-m long and 0.8-m wide, resulting in a density of 20 plants subplot^{-1}. However, the width from the middle of one bed to another was 1.98 m and was used to calculate the yield per hectare for analysis. In-season, row middles for the entire study were weeded using a "G" tractor with Danish-tine cultivator at Vincennes and a Farmall 200 cultivator at Lafayette twice for the first 6 WAP. Weed pressure and size were used to determine cultivation for this 6-wk period. This was supplemented by hoe weeding and hand removal until sweetpotato vines completely covered the row middles.

Weed counts, height (centimeters), and sweetpotato canopy cover were recorded using a 0.09-m^2 quadrat in each subplot at 5, 6, and 7 WAP. The entire subplot was used for weed control ratings at 5, 6, and 7 WAP and sweetpotato canopy cover at 15 WAP. Visual weed control was rated using a scale of 0% (no weed control) to 100% (complete weed control) relative to the corresponding weedy control plot in each replicate. Weed count, control, and height data were collected before removing weeds from plots, including plots subjected to weed removal in the previous week. Sweetpotato canopy cover was visually recorded from the top of the raised beds as an estimate of total ground surface area using a scale of 0% (no cover) to 100% (complete cover). The average height of two representative weeds in each plot was recorded to demonstrate the height of weeds at various times of crop production. These data were collected from two random weeds, regardless of species. At 111 DAP, aboveground biomass in all plots was rotary mowed to remove foliage and facilitate smooth operation of equipment for harvest. Sweetpotato roots were harvested from the entirety of each plot 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), canners (>2.5- to 4.4-cm diameter), or culls (misshapen roots) for each plot (USDA-AMS 2005). The summation of jumbo, U.S. No. 1, canners, and culls is presented as total yield. Percent yield reduction for each grade of each cultivar was calculated based on the mean yield from the weed-free control of the same cultivar within the same location.

Data were subjected to statistical analysis using R software (RStudio®, PBC, Boston, MA). Percentage data (weed control and canopy cover) were arcsin square-root transformed, while weed count data were square-root transformed for normality to meet assumptions of ANOVA. Both the weedy and weed-free control data were excluded from the weed control analysis due to zero variance. Data for both locations were subjected to ANOVA using the split-plot model to test the main effects of weed-free interval and sweetpotato cultivar and their interaction. Weed-free interval and sweetpotato cultivar were treated as whole-plot factor and subplot factor, respectively, and location and replicates as the block factors. When a significant treatment by location interaction ($P \leq 0.05$) existed for a response variable, data were analyzed and presented separately by location. Response variable data were subjected to nonlinear regression analyses using the DRC package in R and fit a three-parameter log-logistic model (Knezevic et al. 2007) using Equation 1:

$$y = \frac{d}{1 + \exp[b(\log x - \log e)]} \qquad [1]$$

where y is the response variable, d is the upper limit, b is the relative slope around e, e is the inflection point, and x is the weed-free interval; or a four-parameter log-logistic model using Equation 2:

$$y = c + \frac{d - c}{1 + \exp[b(\log x - \log e)]} \qquad [2]$$

where y is the response variable, c is the lower limit, d is the upper limit, b is the relative slope around e, e is the inflection point, and x is the weed-free interval.

Results and Discussion

Weed Density, Height, and Control

Weed species and density varied between the two locations. Weeds at Lafayette were barnyardgrass [*Echinochloa crus-galli* (L.) P. Beauv.], velvetleaf (*Abutilon theophrasti* Medik), common ragweed (*Ambrosia artemisiifolia* L.), redroot pigweed (*Amaranthus retroflexus* L.), common purslane (*Portulaca oleracea* L.), common lambsquarters (*Chenopodium album* L.), ivyleaf morningglory (*Ipomoea hederacea* Jacq.), Canada thistle [*Cirsium arvense* (L.) Scop.], and white clover (*Trifolium repens* L.). At Vincennes, the predominant weeds were carpetweed (*Mollugo verticillata* L.), waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer], *A. artemisiifolia*, *C. album*, *P. oleracea*, and large crabgrass [*Digitaria sanguinalis* (L.) Scop.]. We observed that the distribution of weed species was not uniform and varied within each field. During conditions of limited rainfall, the weed population was highest in the middle of the raised bed close to the drip-tape. Weed density and height data at 5 and 7 WAP and weed control data at 7 and 15 WAP were combined across Lafayette and Vincennes locations, because there was no significant treatment by location interaction. Due to a lack of significant sweetpotato cultivar by weed-free period interaction, weed density and height at 5 and 7 WAP and weed control at 7 WAP were pooled across all three cultivars. Weed control at 15 WAP was analyzed separately by cultivar due to significant ($P \leq 0.0002$) differences among cultivars.

Weed density data fit a three-parameter log-logistic model (Figure 1). At 5 WAP, the predicted weed density of the weedy control was 354 plants m^{-2}, and as weed-free period increased from 14 to 42 DAP, predicted weed density decreased from 130 to 68 plants m^{-2} (Figure 1A). At 7 WAP, the predicted weed density of the weedy control was 494 plants m^{-2}, and as weed-free period increased from 14 to 42 DAP, predicted weed density decreased from 374 to 228 plants m^{-2} (Figure 1B). Weed height data at 5 and 7 WAP fit a four-parameter log-logistic model (Figure 2). At 5 WAP, the predicted height of weed species of the weedy control was 61 cm, and as weed-free period increased from 14 to 42 DAP, predicted weed height decreased from 30 to 13 cm (Figure 2A). At 7 WAP, the predicted height of the most predominant weed species

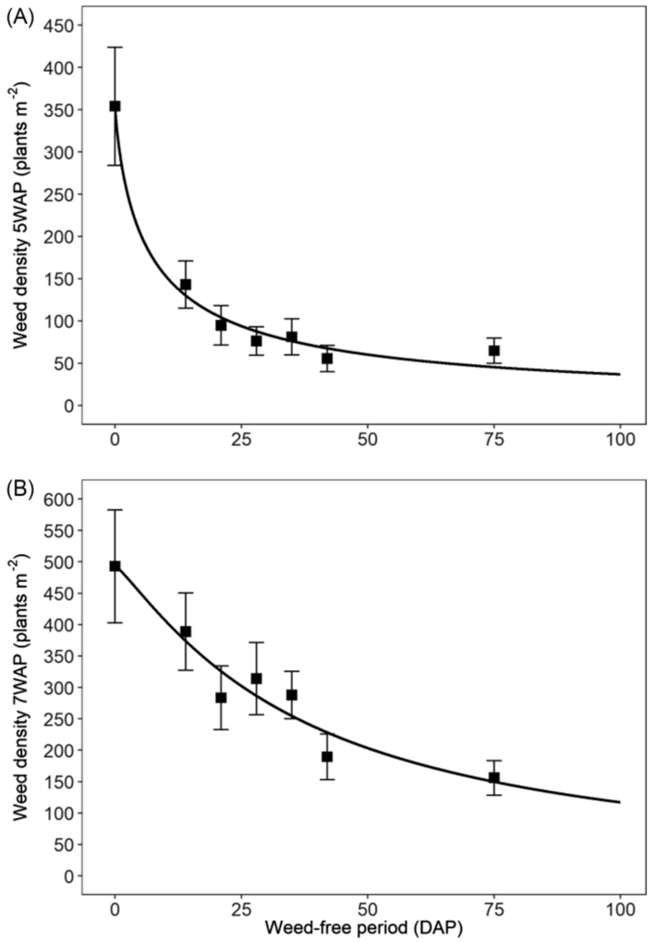

Figure 1. Effect of weed-free period on weed density (A) 5 and (B) 7 wk after transplanting (WAP) pooled across Lafayette and Vincennes in 2022. Points represent observed mean data and lines represent the predicted weed density based on a threeparameter log-logistic model (Equation 1). Parameters for 5 WAP: $b = 0.817$, $d = 354.5$, and $e = 7.175$, with a lack-of-fit P = 0.926; and 7 WAP: $b = 1.172$, $d = 493.7$, and $e = 36.918$, with a lack-of-fit P = 0.77. DAP, days after transplanting.

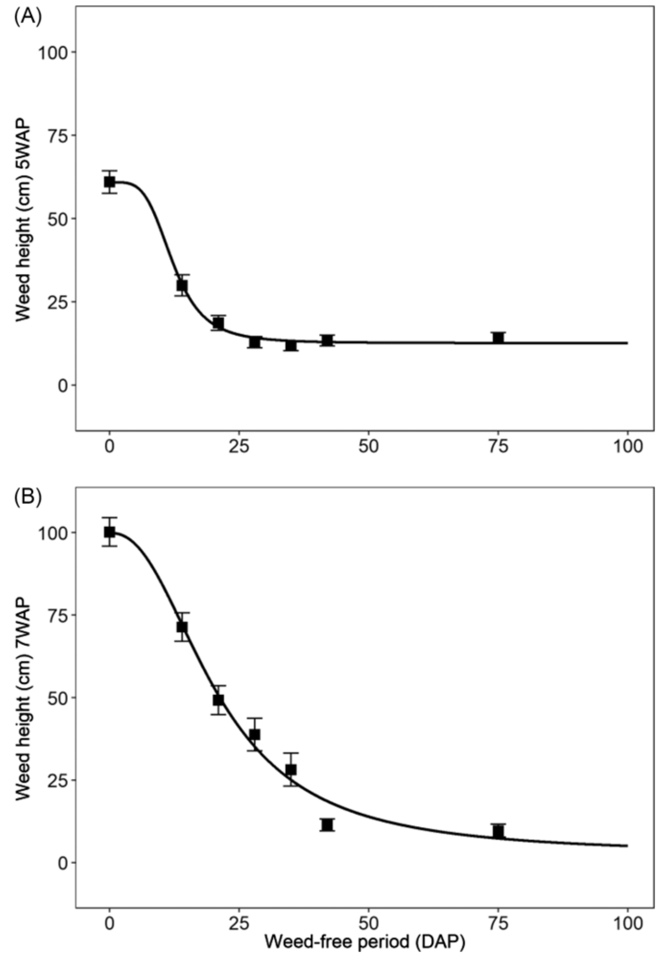

Figure 2. Effect of weed-free period on weed height (A) 5 and (B) 7 wk after transplanting (WAP) pooled across Lafayette and Vincennes in 2022. Points represent observed mean data and lines represent the predicted weed height based on a four-parameter log-logistic model (Equation 2). Parameters for 5 WAP: $b = 4.06$, $c = 12.64$, $d = 60.95$, and $e = 12.17$, with a lack-of-fit P = 0.66; and 7 WAP: $b = 2.3$, $c = 2.54$, $d = 100$, and $e = 20.77$, with a lack-of-fit P = 0.17. DAP, days after transplanting.

of the weedy control was 100 cm, and as weed-free period increased from 14 to 42 DAP, predicted weed height decreased from 72 to 19 cm (Figure 2B). Visual weed control data at 7 and 15 WAP fit a three-parameter log-logistic model (Figure 3). At 7 WAP, as weed-free period increased from 14 to 42 DAP, predicted visual weed control increased from 40% to 97% (Figure 3A). At 15 WAP, as the weed-free period increased from 14 to 42 DAP, visual weed control increased from 27% to 82% for Covington, 27% to 88% for Monaco, and 32% to 97% for Murasaki (Figure 3B).

Sweetpotato Canopy

Data were combined across locations because no significant treatment by location interaction was observed. Data were pooled across cultivar because we observed no significant cultivar by weed-free period interaction at 7 WAP. However, at 15 WAP, sweetpotato canopy cover data are presented separately due to significant cultivar by weed-free period interaction. Percent sweetpotato canopy cover fit a four-parameter log-logistic model (Figure 4A) at 7 WAP and three-parameter log-logistic model (Figure 4B) at 15 WAP. At 7 WAP, the predicted percentage of sweetpotato canopy cover increased from 41% to 98% as the weed-free interval increased from 14 to 42 DAP (Figure 4A). At 15 WAP, as weed-free period increased from 14 to 42 DAP, sweetpotato canopy cover increased from 30% to 87% for Covington, 29% to 89% for Monaco, and 34% to 97% for Murasaki (Figure 4B). At 15 WAP, Murasaki had the greatest numerical canopy cover of the three clones for weed-free intervals of 21, 28, 35, and 42 DAP. All weedy control plots had a 100% canopy cover of weeds at both 7 and 15 WAP. This superiority in vine canopy by Murasaki is likely due to its growth habit, which results in a rapidly formed dense canopy.

Sweetpotato Yield

Pooled across both locations, the observed jumbo yield in hand-weeded control plots was 2,842 kg ha^{-1}, 3,010 kg ha^{-1}, and 2,935 kg ha^{-1} for Covington, Monaco, and Murasaki, respectively. Jumbo yield reduction data fit a four-parameter log-logistic model (Figure 5A). Season-long weed interference reduced jumbo yield by 69% for Covington, 92% for Monaco, and 81% for Murasaki relative to the weed-free control. Observed canner yield in hand-weeded control plots was 3,269 kg ha^{-1}, 1,822 kg ha^{-1}, and 1,943 kg ha^{-1} for Covington, Monaco, and Murasaki, respectively. Canners yield reduction data fit a four-parameter log-

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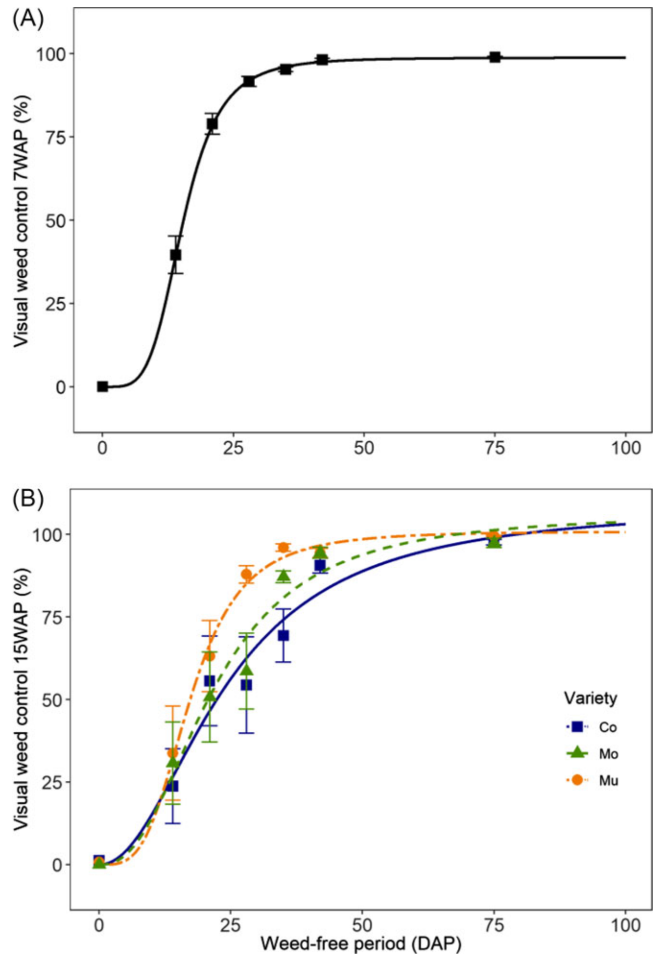

Figure 3. Effect of weed-free period on visual weed control (A) 7 and (B) 15 wk after transplanting (WAP) pooled across Lafayette and Vincennes in 2022. Points represent observed mean data and lines represent the predicted percentage of weed control based on a three-parameter log-logistic model (Equation 1). Parameters for 7 WAP: $b = -4.32$, $d = 98.82$, and $e = 15.35$, with a lack-of-fit P = 0.99; and 15 WAT for Co: $b = -2.06$, $d = 108.62$, and $e = 24.12$, with a lack-of-fit P = 0.56; Mo: $b = -2.41$, $d = 106.41$, and $e = 21.72$, with a lack-of-fit P = 0.55; Mu: $b = -3.52$, $d = 100.97$, and $e = 17.37$, with a lack-of-fit P = 0.93. Abbreviations: Co, Covington; Mo, Monaco; Mu, Murasaki. DAP, days after transplanting.

logistic model (Figure 5B). Season-long weed interference reduced canner yield by 67% for Covington, 61% for Monaco, and 68% for Murasaki relative to the weed-free control.

The observed U.S. No. 1 yield in hand-weeded control plots was 21,114 kg ha^{-1}, 10,869 kg ha^{-1}, and 11,787 kg ha^{-1} for Covington, Monaco, and Murasaki, respectively. U.S. No. 1 yield reduction data fit a three-parameter log-logistic model (Figure 6A). Season-long weed interference reduced U.S. No. 1 yield by 78% for Covington, 86% for Monaco, and 59% for Murasaki relative to the weed-free control. As the weed-free period increased from 14 to 42 DAP, the predicted U.S. No. 1 yield reduction decreased from 59% to 0.5% for Covington, 67% to 10% for Monaco, and 40% to 0.04% for Murasaki. Observed total yield in hand-weeded control plots was 27,225 kg ha^{-1}, 15,701 kg ha^{-1}, and 16,665 kg ha^{-1} for Covington, Monaco, and Murasaki, respectively. Total yield reduction data fit a three-parameter log-logistic model (Figure 6B). Season-long weed interference reduced total yield by 76% for Covington, 88% for Monaco, and 65% for Murasaki relative to the weed-free control.

This is similar to previous observations that demonstrated sweetpotato yield losses of ≥50% when weeds were not controlled

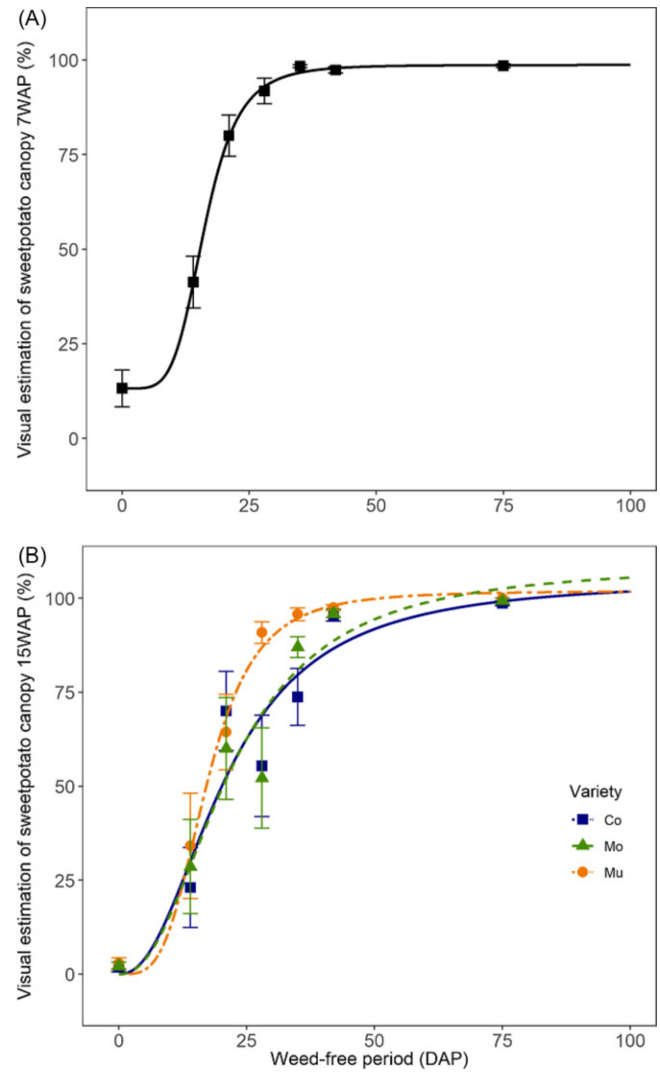

Figure 4. Effect of weed-free period on visual estimation of sweetpotatoes canopy cover of (A) 7 and (B) 15 wk after transplanting (WAP) pooled across Lafayette and Vincennes in 2022. Points represent observed mean data and lines represent the predicted percent of canopy cover based on four- (Equation 2; 7 WAP) and three-parameter (Equation 1; 15 WAP) log-logistic models. Parameters for 7 WAP: $b = -4.838$, $c = 13.216$, $d = 98.68$, and $e = 16.22$, with a lack-of-fit P = 0.96; and 15 WAT for Co: $b = -2.24$, $d = 104.89$, and $e = 20.97$, with a lack-of-fit P = 0.06; Mo: $b = -2.27$, $d = 108.85$, and $e = 21.86$, with a lack-of-fit P = 0.20; Mu: $b = -3.63$, $d = 101.98$, and $e = 17.27$, with a lack-of-fit P = 0.90. Abbreviations: Co, Covington; Mo, Monaco; Mu, Murasaki. DAP, days after transplanting.

(Basinger et al. 2019; Harrison and Jackson 2011; Meyers et al. 2010; Seem et al. 2003). As the weed-free period increased from 14 to 42 DAP, the predicted total yield reduction decreased from 58% to 0.4% for Covington, 70% to 6% for Monaco, and 43% to 0.09% for Murasaki. The estimated weed-free interval required for total sweetpotato yield to reach 90% of the weed-free control in this study was 24 DAP for Covington, 33 DAP for Monaco, and 20 DAP for Murasaki.

Our findings strongly support the idea that delaying weed removal during sweetpotato production significantly reduces yield. The longer weeds were allowed to exist in the crop, the more pronounced the reduction in yield became. Across the three cultivars studied, responses to weed interference in terms of yield reduction varied. Murasaki exhibited a comparatively lower decrease in U.S. No. 1 yield due to weed interference compared

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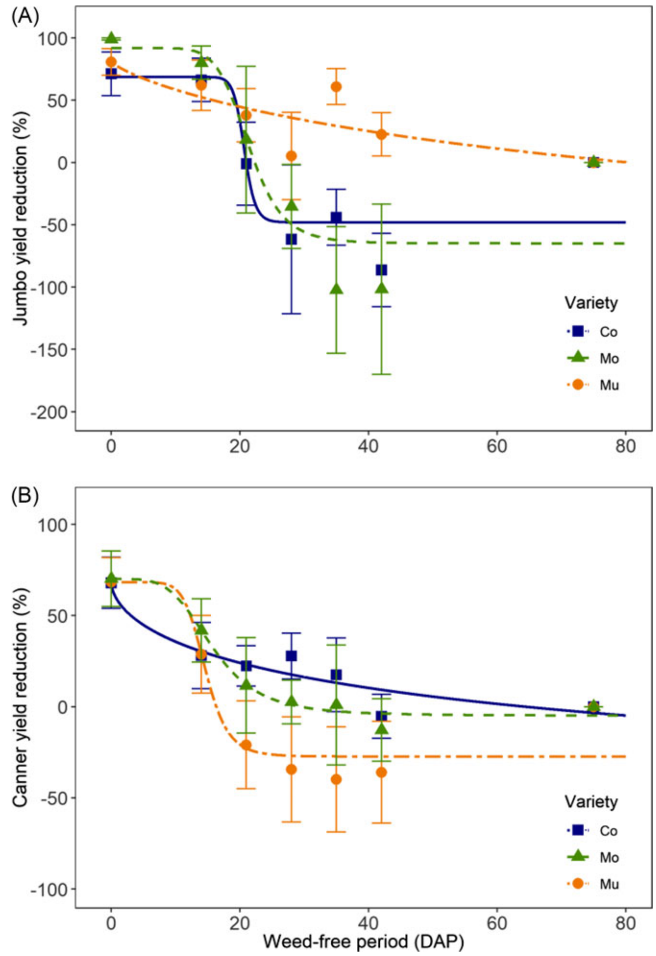

Figure 5. Effect of weed-free intervals (DAP, days after transplanting) on (A) jumbo yield reduction and (B) canners yield reduction of sweetpotato roots pooled across Lafayette and Vincennes in 2022. Points represent observed mean data and lines represent the predicted percent reduction of jumbo and canner yield based on a four-parameter log-logistic model (Equation 2). Parameters for (A) Co: $b = 24.17$, $c = -47.98$, $d = 68.76$, and $e = 20.66$, with a lack-of-fit $P = 0.25$; Mo: $b = 8.19$, $c = -64.78$, $d = 92.11$, and $e = 21.36$, with a lack-of-fit $P = 0.24$; Mu: $b = 0.8$, $c = -122.36$, $d = 81.09$, and $e = 134.84$, with a lack-of-fit $P = 0.16$; and (B) Co: $b = 0.59$, $c = -83.39$, $d = 67.96$, and $e = 91.32$, with a lack-of-fit $P = 0.62$; Mo: $b = 4.06$, $c = 12.64$, $d = 60.95$, and $e = 12.17$, with a lack-of-fit $P = 0.20$; Mu: $b = 8.31$, $c = -27.26$, $d = 68.38$, and $e = 14.61$, with a lack-of-fit $P = 0.58$. Abbreviations: Co, Covington; Mo, Monaco; Mu, Murasaki.

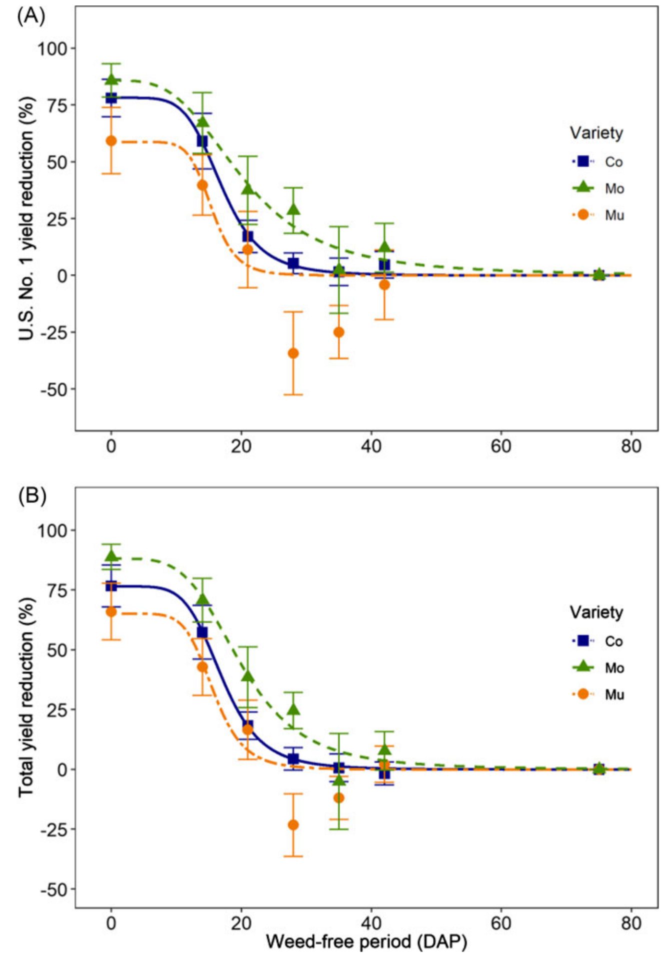

Figure 6. Effect of weed-free intervals (DAP, days after transplanting) on (A) U.S. No. 1 yield reduction and (B) total yield reduction of sweetpotato roots pooled across Lafayette and Vincennes in 2022. Points represent observed mean data and lines represent the predicted percent reduction of U.S. No. 1 grade and total yield based on a three-parameter log-logistic model (Equation 1). Parameters for (A) Co: $b = 5.668$, $d = 78.239$, and $e = 16.976$, with a lack-of-fit $P = 0.98$; Mo: $b = 3.339$, $d = 85.885$, and $e = 20.203$, with a lack-of-fit $P = 0.88$; Mu: $b = 8.279$, $d = 58.815$, and $e = 15.435$, with a lack-of-fit $P = 0.06$ and (B) Co: $b = 5.653$, $d = 76.549$, and $e = 17.025$, with a lack-of-fit $P = 0.99$; Mo: $b = 4.188$, $d = 88.147$, and $e = 19.928$, with a lack-of-fit $P = 0.72$; Mu: $b = 6.755$, $d = 65.139$, and $e = 15.703$, with a lack-of-fit $P = 0.11$. Total yield was the sum of U.S. No.1, jumbo, and canner + cull grade storage roots. Abbreviations: Co, Covington; Mo, Monaco; Mu, Murasaki.

with Covington and Monaco. This discrepancy can be linked to the growth characteristics of these cultivars: Murasaki and Covington, characterized by longer vines and an open canopy, were less affected, whereas Monaco, with its compact and dense growth habit, experienced more substantial interference. The substantial reduction in yield observed in the Monaco variety might also be linked to its poor crop establishment. Notably, Murasaki displayed vigorous growth and established its canopy faster than the other cultivars, suggesting a higher tolerance to weed interference. However, while Covington yielded more than Murasaki, it experienced a greater reduction in yield when weeds were present. This underscores the importance for breeders to aim for a cultivar that is both weed-tolerant and high-yielding, considering these factors together in breeding programs.

Huarte and Benech-Arnold (2003) noted a decrease in weed emergence beneath an alfalfa (*Medicago sativa* L.) crop canopy, which they linked to a reduction in the red to far-red light ratio (R:FR). They found that the R:FR ratio was lower at the soil surface under the alfalfa canopy (ranging from 0.05 to 0.3) compared with areas without crop (which measured 1.15). Similarly, in our own plots, we observed a decline in weed emergence after 8 WAP across all cultivars (data not presented). This decrease in weed emergence could be attributed to the shading effect created by the sweetpotato canopy. Enhancing light interception by crops while limiting light availability to weeds increases a crop's competitive ability.

Cultivars are often categorized as either weed suppressive or weed tolerant. A weed-tolerant cultivar maintains its yield even in the presence of weeds, while a weed-suppressive cultivar not only sustains its yield but also curtails weed growth in terms of emergence, height, or biomass (Cosser et al. 1997). Weed-suppressive ability by crops has been linked to early canopy development and plant density (Batlla and Benech-Arnold 2014; Brennan and Smith 2005; Kruk et al. 2006). In potato-cropping (*Solanum tuberosum* L.) systems, cultivar weed tolerance is

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associated with achieving canopy closure early in the season (Colquhoun et al. 2009). La Bonte et al. (1999) identified three sweetpotato cultivars exhibiting bunch or medium-internode growth habits as weed tolerant among the 11 clones they evaluated. Weed suppression can be associated with rapid crop emergence and efficient nutrient uptake that improve leaf area index and tiller and axillary shoot number as reported for cereal species (oats [*Avena sativa* L.], barley [*Hordeum vulgare* L.], and wheat [*Triticum aestivum* L.]) and sweetpotatoes (Seavers and Wright 1999; Workayehu et al. 2011), respectively.

The current research offers significant insights into three cultivars cultivated in central and southern Indiana conditions. Our findings are pivotal for assisting growers in choosing the right cultivar for organic sweetpotato production. Additionally, they shed light on the optimal weed control duration tailored to each cultivar. Nevertheless, a significant hurdle remains in our limited comprehension of how diverse natural weed populations impact sweetpotato growth. Future studies should concentrate on investigating additional cultivars, estimating CTWR for distinct geographic regions, and leveraging growing degree days to generalize CPWC.

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