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Evaluation, Characterization, and Utilization of Weed-Suppressive Sweetpotato Cultivars for Sustainable Weed Management

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Evaluation, Characterization, and Utilization of Weed-Suppressive Sweetpotato Cultivars for Sustainable Weed Management

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by

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Abstract

Sweetpotato (*Ipomoea batatas* L.) is a low-technology, subsistence crop that enhances food and nutrition security particularly in developing nations. Weed interference with the crop can reduce sweetpotato storage root yields and product quality. Current weed management practices in sweetpotato include PRE or POST herbicides application, cultivation, mowing, or handweeding. Unlike row crops, herbicide options for sweetpotato are few; therefore, alternative weed control practices are needed. The overall objective of this research was to determine the weed suppressive ability of several sweetpotato cultivars. This research also provides information about cover crop use for weed suppression in sweetpotato production in Arkansas. Field experiments were conducted in Fayetteville and Kibler to assess the weed suppressive ability with or without full-season interference of broadleaf spp., grass spp., or sedges spp.. Data collected included leaf area index (LAI), vine length, canopy height, weed biomass, and sweetpotato yield by grade. Four sweetpotato cultivars were selected from this study and integrated with winter cover crops in a second set of field experiments conducted in Kibler and Augusta, AR. A mixed combination of cereal rye (*Secale cereale* L.) + crimson clover (*Trifolium incarnatum* L.), and winter wheat (*Triticum aestivum* L.) + crimson clover was compared to a fallow ground control. Data collected were vine length, canopy height, weed biomass, cover crop biomass, and sweetpotato yield by grade. ‘Heartogold’, ‘Centennial’, and ‘Stokes Purple’ were found to have allelopathic activity in greenhouse setting. These results were confirmed in the field experiments. ‘Heartogold’ was strongly weed suppressive for both grass spp. and broadleaf spp., and yellow nutsedge (*Cyperus esculentus* L.). ‘Hatteras’ and ‘Centennial’ significantly reduced yellow nutsedge growth. These three cultivars have short vines and upright growth. Cultivars with long vines were generally less competitive with weeds. Canopy height and LAI were not correlated with weed suppression, indicating the contribution of another factor toward weed suppression. The most weed-suppressive cultivars were not always the highest yielding. ‘Beauregard-14’ and ‘Bayou Belle-6’ performed better in fields with broadleaf or grass weeds. ‘Bayou Belle-2’, ‘Bayou Belle-6’, ‘Hatteras’, and ‘Centennial’ yielded more in fields infested with yellow nutsedge. Vine length and LAI were positively correlated with jumbo, no.1, and total sweetpotato yield. A mix of cereal rye + clover is a suitable choice for a reduced-till, organic sweetpotato system. This cover crop mixture provided a higher weed suppression compared to that of winter wheat + crimson clover and resulted in numerically higher sweetpotato yields. Altogether, this research showed that there are commercially acceptable, weed-suppressive sweetpotato cultivars and these types of cultivars should be utilized to breed cultivars for commercial production. Weed-suppressive cultivars should be used as a tool for integrated weed management to reduce weed infestation levels, which leads to better performance of herbicides in conventional production and reduced handweeding cost in either conventional or organic sweetpotato production. Furthermore, planting weed-suppressive cultivars will complement the efficacy of cover crops in reducing early-season weed infestation, providing extended weed suppression after the activity of allelochemicals from the cover crop had dissipated and the sweetpotato has established.

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Dedication

To the memory of my father, *Daniel Moerschbaecher Werle*.

You will forever remain alive in my heart.

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Introduction

Sweetpotato (*Ipomea batatas* L.) is the sixth most important food crop in the world behind rice, wheat, potato, maize, and cassava (International Potato Center [CIP], 2022). The worldwide sweetpotato production is estimated to be over 105 million metric tons per year, and 95% out of this total comes from economical developing countries (CIP, 2022). China is the biggest sweetpotato producer and consumer, where it is used as human food, animal feeding, and product processing (United States Department of Agriculture [USDA], 2015). In the United States, sweetpotato has been cultivated in 61,000 ha on average over the past five years, with an annual production value of over $650 million (National Agricultural Statistics Service [USDA-NASS], 2022). The highest sweetpotato production is concentrated in the Southern United States which has warmer climates and longer frost-free period relative to other regions in the country.

Sweetpotato is clonally propagated and commonly transplanted in the field from early May to late June (Kemble, 2011). Slips of 20 to 25 cm in length are transplanted into fields previously plowed to form ridged rows that are 30 to 40-cm tall (Schultheis et al., 1999). Despite its perennial life cycle, sweetpotato is generally harvested within 3 to 4 months. The storage root yield is determined by the number of sweetpotato plants per hectare, number of storage roots per plant, and root size (Meyers et al., 2014). The time between field preparation and sweetpotato transplanting varies depending on weather conditions or the specific grower. As interval between these two operation increases, weed emergence increases. If weeds are near emergence or emerged, they have a competitive advantage over the crop as sweetpotato takes a relatively long time to close its canopy.

The critical period for weed competition in sweetpotato starts at 7 days after transplanting (DAT) goes up to 56 (DAT); the most critical time is between 30 to 45 DAT when roots are developing (Levett, 1992). Sweetpotato vines form a closed canopy only after the sixth week. Thereafter, weeds have minimal effect on storage root yields (Seem et al., 2003). Typical early season weed control is accomplished by farmers using PRE or POST herbicides, cultivation, mowing, or handweeding. Herbicide options are few in sweetpotato production. As of 2022, only six herbicides are register for sweetpotato in Arkansas including: sethoxydim, clethodim, clomazone, fluazifop, *S*-metolachlor, and flumioxazin (MP44, 2022). Except for sethoxydim and clethodim, the other herbicides are more effective preemergence (clomazone and flumioxazin) than postemergence or has solely preemergence activity as in the case of *S*-metolachlor and have a primarily activity on grass species. Broadleaf weeds must be removed by hand from sweetpotato fields, which is labor intensive and costly. Hence, sweetpotato production will increasingly require an integrated weed management system (IWM) for weed control.

One way to complement current cultural and chemical weed control methods is using cultivars with a superior competitive ability against weeds. Sweetpotato cultivars vary in growth pattern (i.e., erect, semierect, branching), leaf size, root shape and color, and overall yield potential (Amankwaah, 2012; La Bonte, 1999; Wubanechi, 2014; Xuan, 2016). These growth traits can be associated with the ability of a given cultivar to suppress, compete, and withstand weeds in the field. Early vigor, rapid canopy closure, leaf area, canopy height, and overall growth habit have been documented to increase crop competitiveness to weeds (Hansen et al., 2008, Mason et al., 2008, Sweet et al., 1974, Trezzi et al., 2013). Another factor that can contribute to weed suppression is allelopathy. Essentially, allelopathic cultivars are those that exude chemical substances capable of hindering weed growth (Harrison & Peterson, 1986). Allelochemical compounds have been identified in several sweetpotato cultivars and include coumarin, transcinnamic acid, o-coumaric acid, p-coumaric acid, caffeic acid, and chlorogenic acid (Chon & Boo, 2005; Soni et al., 2019; Xuan et al., 2016). The combined effects of crop competition and allelopathy determine the total weed suppressive potential of a crop cultivar (Bertholdsson et al., 2012, Mwendwa et al., 2020, Worthington et al., 2013).

Other agronomic practices such as the use of cover crops can provide an additional option for weed suppression. Cereal cover crops such as cereal rye and winter wheat produce a large quantity of biomass. In reduced-till or no-till systems, where the biomass remains on soil surface, cover crop residues keep the ground covered and prevent light from reaching the soil surface, which inhibits small seeded annual weeds from emerging in the field (Davis, 2010; Mirsky et al., 2013; Teasdale & Mohler, 1993). Legume cover crops are commonly grown in mixture with cereal grains since they provide good amount of nitrogen fixation in the soil and generally have a low C:N ratio, which allows a quicker decomposition (Finch, 1993; McKinlay et al., 1996; Theunissen & Schelling, 1996). With the decomposition of leguminous cover crop-residues, plant-available nitrogen is released and can be taken up by the following cash crop (Roberts et al., 2018). In a long-term weed management program, the integration of superior sweetpotato genotypes and cover crops suppresses weeds without adverse effects on the environment and reduces the need for herbicides. Implementing these into a current weed management program should also prevent further evolution of herbicide-resistant weeds.

The present research characterizes sweetpotato cultivars with superior weed suppressive ability and determines whether allelopathic properties and canopy architecture traits are correlated with differential weed suppression. This research also provides information on the utilization of cover crops for weed suppression in organically grown sweetpotato in Arkansas.

Review of Literature

Weed interference in sweetpotato production

The critical time for weed interference in sweetpotato is between 7 to 56 days after transplanting (DAT). The storage root initiation occurs between 30 to 45 DAT and it is strongly correlated with the final number of roots and sweetpotato total yield (Levett, 1992). The last third of the growing season is when storage roots size up with reserve supplies. These phases vary with cultivars, climatic conditions, and cultural practices (Monks et al., 2019).

Grasses can affect sweetpotato yield because of their ability to grow through tiny gaps in the sweetpotato canopy then grow bigger above r the sweetpotato plants (Meyers & Shankle, 2015). Common problematic annual grasses in sweetpotato fields include large crabgrass (*Digitaria sanguinalis* L.), goosegrass (*Eleusine indica* L.), barnyardgrass (*Echinochloa crus-galli* L. P. Beauv.), and broafleaf signalgrass [*Urochloa platyphylla* (Munro ex C.Wright) R.D.Webster] (Monks, 2019). The grass species composition infesting the field is dependent on the field history, location, and overall field operations. Farmers till the field before sweetpotato transplanting to prepare the beds. However, grasses emerge soon after land preparation and, without supplemental control measures, will interfere with sweetpotato growth in the early season.

Palmer amaranth (*Amaranthus palmeri* S. Watts) is the major weed in sweetpotato production. Because of its rapid growth, Palmer amaranth is can overgrow sweetpotato plants within two to three weeks and can reduce 36 to 81% of storage root yield if present at 0.5 to 6.5 plants per meter of row (Meyers & Shankle, 2015; Monks et al., 2019). If left uncontrolled in the first three weeks after sweetpotato transplanting, yield reduction can be up to 90% (Smith et al., 2020).

Yellow nutsedge (*Cyperus esculentus* L.) and purple nutsedge (*Cyperus rotundus* L.) are among the most troublesome weed species in sweetpotato fields. The perennial life cycle and vegetative reproduction by underground tubers favor a rapid distribution of this weed in the field. For instance, yellow nutsedge densities can increase 7% within 4 months (Meyers & Shankle, 2015). Sweetpotato marketable yield can be reduced by 18% and 80% when yellow nutsedge density is 5 and 90 shoots m^{-2}, respectively (Meyers & Shankle, 2015).

Weeds that belong to the morningglory family (*Ipomoea* spp.) are commonly observed in sweetpotato fields. If present, these species are the most difficult to control (or cannot be controlled) among all weeds infesting sweetpotato. These species have similar morphology to sweetpotato plants and easily intertwine with sweetpotato plants, becoming impossible to control (Price & Wilcut, 2007). Fields infested with morningglories should be avoided. Other weeds commonly observed weeds in sweetpotato fields include common purslane (*Portulaca oleracea* L.), Pennsylvania smartweed (*Polygonum pensylvanicum* L.), Florida pusley (*Richardia scabra* L.), common lambsquarters (*Chenopodium album* L.), prickly sida (*Sida spinosa* L.), Hophornbeam copperleaf (*Acalypha ostryifolia* Ridell), and several Solanaceae species (*Solanum* spp.) (Monks et al., 2019).

Weed suppression, weed tolerance, and weed competition

A weed-tolerant cultivar can be defined as one that maintains its yield in the presence of weeds, not necessarily implying any reduction on weed growth (Cosser et al., 1997). The ability of a crop to reduce weed growth in terms of emergence, biomass, and seed production is defined as weed suppressive ability (Goldberg, 1990; Grace, 1990).

The weed suppressive ability is trigged by several plant traits which varies between cultivars. Weed suppression is associated with rapid crop emergence and growth, early and abundant tillering, high leaf area index (LAI), efficient nutrient uptake, and increased canopy height (Andrew et al., 2014; Appleby et al., 1976; Champion et al., 1998; Didon, 2002). The weed suppressive ability of cereal cultivars has been well documented. In barley, greater leaf area and height, tillering, and early establishment was associated with weed suppression (Brain et al., 1999; Hansen et al., 2008; Seavers & Wright, 1997). In a study comparing 13 winter wheat cultivars, total annual weed density and mature winter wheat height were negatively correlated, suggesting that tall cultivars are likely to suppress weed growth (Wicks et al., 2004). Interestingly, two of the shortest cultivars in the study exhibited stronger suppressive abilities than many tall cultivars. This result indicates that more than one trait is involved in weed suppression ability and that allelopathy could be a stronger contributor to weed suppression than superior crop morphological traits. The benefit of plant height, leaf mass, and indeterminate growth habit was also important for weed suppression in soybean experiments (Newcomer et al., 1986; Trezzi et al., 2013).

The morphological traits contributing to the weed suppressive ability of sweetpotato cultivars and other vegetable crops is limited. Cultivars with upright growth have been indicated as better weed suppressors than those with spreading, viney growth habit (Harrison Jr. and Jackson 2011). In studies with 11 sweetpotato cultivars grouped based on their growth habit (bunch vs. trailing vine), no group possessed a superior canopy architecture favoring weed suppression (La Bonte, 1999). Correlation analysis revealed that sweetpotato canopy surface was not important for weed biomass suppression at 42 DAT. However, the canopy surface area was not different across cultivars at the time of evaluation, meaning that sweetpotato clones had not yet formed a closed canopy at 42 DAT. In other crops such as potato, a dense, close canopy enhances weed suppression (Sweet et al., 1974). Feakin (1973) suggested that peanut cultivars with erect growth habit are more tolerant to weeds than those with longer vines. Cultivars with longer vines tend to have a prostrate, running growth habit, which allows more sunlight to infiltrate the open spaces between vines and favor weed growth.

A significant portion of the observable phenotypic variation expressed among cultivars cannot be explained solely by morphological traits. For instance, in a study with barley and wheat cultivars, early crop biomass explained up to 57% of the observed cultivar effect on weed biomass across four years of experimentation (Bertholdsson, 2005). Allelopathic activity explained 7 to 58%. When combined, both traits explained 44 to 69% of the weed suppression ability. In wheat, 14 to 21% of weed suppression was explained with for early crop biomass, 0 to 21% for allelopathic activity alone, and 27 to 37% when both mechanisms were combined (Bertholdsson, 2005). These findings suggest that combined effects of both competitive crop ability and allelopathic activity contribute to weed suppression in cereals. More details of the allelopathic properties in crop cultivars and is discussed in the next section.

Allelopathy

Plants interact with neighboring species chemically and physically. Plant-plant interaction involves competition and allelopathy, collectively known as interference. Competition is the consequence of plants using a limited supply of the same resources, whereas allelopathy is the inhibitory effect of chemicals released by one plant to neighboring plants (Molisch, 1937). The chemical compounds released by allelopathic plants are often referred to as allelochemicals or secondary plant metabolites (Radosehich et al., 2007; Zimdahl, 2007).

Allelochemical families can be divided in 14 categories (Rice, 1974): long-chain fatty acid, unsaturated lactones, benzoquinone, anthraquinone, and complex quinones; phenol, benzoic acids, cinnamic acid coumarin, flavonoids, tannins, terpenoids and steroids; amino acids, peptides; glucosinolates, sulfide, purines, and nucleosides organic acids, straight-chain alcohol, aliphatic aldehydes, and ketones. Putnam (1985) classified allelochemicals into various groups includingorganic acids and aldehydes, aromatic acids, unsaturated lactones, coumarins, quinones, flavonoids, tannins, alkanoids, terpenoids and steroids, long chain fatty acids, alcohols, polypetides, and nucleosides. The activity of these allelochemicals is complex and the final effect can be derivate from a mixture of several compounds (Einhellig, 1995).

The diversity of allelochemicals is vast and varies according to the environment factors, part of the plant, and plant life cycle. Allelochemical compounds may be found in any kind of plant organs, including stems, leaves, flowers, fruit, roots, tubers, or seeds. These compounds can enter the environment through plant residue decomposition, volatilization, or root exudation and move through soil by leaching (Radosevich et al., 2007; Zimdahl, 2007). While soil microbes could aid in the dissipation of allelochemicals in soil, microbial activity could also produce metabolites that are more phytotoxic than the parent allelochemicals. Therefore, the science of allelopathy is complex. Although leaves are considered the most consistent source (Putnam 1985), root exudates are important in terms of availability of the chemicals directly into the rhizosphere (Inderjit & Weston 2003). When released in the environment, the flux rate of these chemical substances may vary because its degradation or transformation in other compounds (Inderjit & Duke, 2003). Phenolics and alkaloids, for example, are leached by rain, fog, snow, or after the residue decomposition in the soil; while root exudation process releases scopoletin and hydroquinone compounds (Gallet & Pellissier, 1997).

Toxic biochemicals is not the only form of allelopathy interference between plants. Morris et al. (2009) suggests that elemental allelopathy can also play a role on how plants interfere with one another. In this case, a plant is able to increase the level of a particular element in a way that is toxic to its neighbor (receiver) but tolerated by the allelopathic plant (donor). Heavy metal, salts, and sulfur accumulation in high concentrations can be implicated in allelopathic suppression. This mechanism occurs by altering the rhizosphere chemistry via hyperaccumulation or litter deposition.

Allelochemicals are important components of plant defense mechanism. The findings of putative allelochemicals can possibly help with the existing problems in weed control and propose future research and directions to provide a useful strategy for farming systems. Optimizing allelopathy traits enhance the breeding of competitive cultivars with superior weed-suppression. Furthermore, with the increasing emphasis of organic traits in food production, allelochemicals can have a great act as environmentally friendly herbicides.

Allelopathy in sweetpotato

The content of secondary compounds is variable upon the sweetpotato genotypes and explain why the screening of an extensive sweetpotato germplasm can result in the discovery of sweetpotato genotypes with high weed suppression ability. Xuan et al. (2016) reported that weed inhibition through allelopathy is variety dependent. In their study, only three (‘Yen 615’, ‘36’, and ‘54’) of the 48 cultivars achieved more than 90% of inhibition of cogongrass (*Imperata cylindrica* L.) emergence. Overall, the height and density of cogongrass were inhibited by 19 and 40%, respectively when grown with sweetpotatoes. In the same research, common beggarsticks (*Bindens Pilosa L.*) and goatweed (*Ageratum conyzoides* L.) density were reduced from 6 to 0.2 and from 33.8 to 7.8 plants m^{-1}, respectively, in competition with sweetpotato.

Xuan et al. (2016) identified sweetpotato allelochemicals through gas chromatography-mass spectrometry (alGC-MS) with different extracts, including water, ethanol, and hexane. These metabolites were found in stems, leaves, and root exudates of the sweetpotato plants. The authors suggested that numerous water-soluble allelochemicals are present in sweetpotato. In total, eight compounds were detected, including phenols, long-chain fatty acids, and phenolics, and sterol. Among these compounds, 5-(dimethoxy methyl)-2-furyl) methanol and methyl ester-2-furoic acid may have high biological activities against weeds species.

Chon & Boo (2005) found the highest amount (97 mg) of phenolic compounds in leaf sample extracts of three colored cultivars, followed by stems (65 mg), and roots (18 mg). The cultivar ‘Sinyulmia’ inhibited alfalfa root length 96% at 40 g $^{-1}$ of leaf extracts, while the stem and root extracts reduced alfalfa root lengths by 87 % and 85 %, respectively. In contrast, the cultivar ‘Sinhwangmi’ and ‘Jami’ showed the less inhibitory effect of leaf extracts (64 % each), while stem had 86–83 % and root extracts 87–97 %. Therefore, allelochemical concentrations (or production) differ among plant tissues and cultivars. Allelopathic substances identified in this experiment were coumarin, transcinnamic acid, o-coumaric acid, p-coumaric acid, caffeic acid, and chlorogenic acid. Chlorogenic acid and caffeic acid were detected in all fractions as the greatest components, with 62 mg 100 g^{-1} and 33 mg 100 g^{-1}, respectively.

Soni et al. (2019) quantified five allelochemicals involved in sweetpotato allelopathy by using high-performance liquid chromatography (HPLC) of water samples. Secondary compounds included caffeic acid and chlorogenic acid were observed in ten cultivars of sweetpotatoes; while coumarin, trans-cinnamic acid, hydroxycinnamic acid were randomly distributed. The cultivars ‘Heartogold’ and ‘529’ were obtained from Lousiana (USA) and Guatemala, respectively, and presented the highest amount of allelochemical compounds in the study. These cultivars were defined as potentially allelopathic and showed a suppressive ability against Palmer amaranth. In the presence of the cultivars ‘529’ and ‘Heartogold’, Palmer amaranth biomass and height were reduced by 80%, and 39%, respectively. ‘Centennial’, ‘Morado’, and ‘Spokes Purple’ presented a high concentration of coumarin and caffeic acid were classified as having intermediate allelopathic potential but showed poor weed inhibition. These results suggest that inhibitory compounds may vary among cultivar genotypes.

To date, only a few studies have been conducted to verify the allelopathic effects of sweetpotatoes on nutsedges. According to Harrison & Peterson (1986), yellow nutsedge was inhibited by 50% of root and more than 40% of shoot length when grown in soil taken from around sweetpotato cultivars ‘SC 1149-19’ and ‘Regal’ in the field. Shoot of yellow nutsedge had chlorotic symptoms and was less vigorous when grown in soil previously cultivated with sweetpotato. Rhizome and tuber dry weights were reduced by 40% compared to the soil from a weedy plot. Similar results were found in greenhouse studies with yellow and purple nutsedge planted together with sweetpotato plants (Harrison & Peterson, 1995). Yellow nutsedge plants had the number of tubers, length and dry weight of total shoot reduced in 43, 31, and 35 %, respectively, when planted together with sweetpotato. Shoot totals of purple nutsedge were higher interfered compered to yellow nutsedge. Dry weight and length were inhibited accordingly by 36 and 69%, while the number of tubers showed only 19 % inhibition.

Other research has shown that sweetpotato has allelopathic effects on bittervine (*Mikania micrantha* L.). Shen et al. (2017) tested the allelopathic response from water extract and soil incorporation from leaves of the sweetpotato cultivars ‘SP1’, ‘SP0’, and ‘SP9’. This study showed that ‘SP1’ had the greatest inhibition among the cultivars. Stem height was reduced 47.40 and 5.10% at concentrations 0.1 and 0.0125 g mL^{-1} for water extract; while 40.12, and 27.44% of stem height was inhibited at concentrations 0.1 and 0.0125 g g^{-1} for soil incorporation. ‘SP1’ also presented the highest inhibition levels for bittervine total biomass, ranging from 10.37-98.15% at concentrations 0.0125-0.1 g mL^{-1} /g g^{-1} in both leaf water extract and leaf incorporated to soil.

Cover crop use in sweetpotato production

Cover crop is any non-cash crop with the purpose of attaining positive effect on soil and/or subsequent crash crop. Cover crops are usually selected based on the residue persistence and biomass production. Cereal grains and legumes cover crops can increase soil organic matter, soil quality, water infiltration in soil, reduced soil erosion and compaction, and provide suppress growth of certain weed species (Clark, 2007; Peoples et al., 1995; Wang et al., 2008).

Grass cover crops such as rye (*Secale cereale* L.) and winter wheat (*Triticum aestivum* L.) are typically planted in the fall and produce large amount of biomass at low seeding rates. (Boyd et al., 2009). Winter wheat is known to enhance soil organic matter (Clark, 2007) and to improve physical conditions of the soil (Roberts et al., 2018). Cereal rye improve soil reduce soil erosion and compaction and can also release secondary metabolites that accumulate on the soil surface and inhibit the germination of weed seeds. In laboratory bioassay with aqueous extracts, small-seeded grasses were highly suppressed by rye cultivars that presented largest amount of hydroxamic acids (Burgos et al., 1999). Benzoxazinoid compounds present in rye shoots are known to exhibit allelopathic effects on giant foxtail (*Setaria faberi* Herm.), common lambsquarters (*Chenopodium album* L.), pigweeds (*Amaranthus* spp.), horseweed (*Conyza canadensis* L.) and barnyardgrass (*Echinochloa crus-galli* L.) (Burgos & Talbert, 1996; Przepiorkowski & Gorski, 1994).

Crimson clover (*Trifolium incarnatum* L.) is a common leguminous cover crop grown in the United States. Legume cover crops such as clover and vetches (*Vicia* spp.) are beneficial for soil properties and can provide good amount of nitrogen fixation in the soil (Finch, 1993; McKinlay et al., 1996; Theunissen & Schelling 1996). Crimson clover can provide up to 168 kgha^{-1} nitrogen when grown throughout the winter and terminated at bloom stage (Clark, 2007). Legume cover crops tend to have a low C:N ratio and are quickly decomposed, leaving room for weed emergence. Grass cover crops release limited amount of N in the soil; however, they have high weed suppressive ability because of its high biomass production. As a result, it keeps the ground covered and prevent the light from reaching the soil surface, thus weeds that do not germinate under shade will not be able to emerge (Davis, 2010; Mirsky et al., 2013; Teasdale & Mohler, 1993). Cereal grain and legume cover crops can be grown in mixture to maximize their benefits to the subsequent cash crop (Reberg-Horton et al., 2012; Vann et al., 2017). In terms of sustainable agriculture, in addition to soil nutrient contribution, cover crops are a good option to minimize the extensive tillage operations, which are common practices in monoculture systems.

References

Amankwaah, V.A. (2012). *Phenotypic and Molecular Characterization of Released and Elite Sweetpotato Varieties in Ghana Compared with Virus-tested Putative Ramets*. [Doctoral Dissertation, Kwame Nkrumah University of Science and Technology]. Kumasi, Ghana. http://ir.knust.edu.gh/xmlui/handle/123456789/4536

Andrew, I.K.S., Storkey J., & Sparkes, D.L. (2014). A review of the potential for competitive cereal cultivars as a tool in integrated weed management. *Weed Research*, *55*, 238-248.

Appleby, A.P., Olson, P.D., & Colbert, D.R (1976). Winter-wheat yield reduction from interference by Italian ryegrass. *Agronomy Journal*, *68*, 463-466.

Bertholdsson, N. O. (2005). Early vigour and allelopathy–two useful traits for enhanced barley and wheat competitiveness against weeds. *Weed Research, 45*, 94-102.

Bertholdsson, N.-O., Andersson, S.C., & Merker, A. (2012). Allelopathic potential of *Triticum* spp., *Secale* spp. and *Triticosecale* spp. and use of chromosome substitutions and translocations to improve weed suppression ability in winter wheat. *Plant Breeding*, *131*, 75-80.

Burgos, N.R., & Talbert, R.E. (1996). Weed control and sweet corn (*Zea mays* var. rugosa) response in a no-till system with cover crops. *Weed Science*, *44*, 355-361.

Burgos, N.R., Talbert, R.E., & Mattice, J.D. (1999). Cultivar and age differences in the production of allelochemicals by *Secale cereal*. *Weed science*,*47*, 481-485.

Boyd, N.S., Brennan, E.B., Smith, R.F., & R. Yokota. (2009). Effect of Seeding Rate and Planting Arrangement on Rye Cover Crop and Weed Growth. *Agronomy Journal*, *101*, 47-51.

Champion, G.T., Froud-Williams R.J., & Holland, J.M. (1998). Interactions between wheat (*Triticum aestivum* L.) cultivar, row spacing and density and the effect on weed suppression and crop yield. *Annals of Applied Biology*, *133*,443-453.

CIP. International Potato Center (2022). *Sweetpotato Facts and Figures*. https://cipotato.org/sweetpotato/sweetpotato-facts-and-figures

Chon, S.U., & Boo, H.O. (2005). Difference in Allelopathic Potential as Influenced by Root Periderm Colour of Sweet Potato (*Ipomoea batatas*). *Journal of Agronomy and Crop Science*, *191*, 75-80.

Clark, A. (2007). Managing cover crops profitably. (3rd ed.). Sustainable Agriculture Research and Education (SARE) Handbook Series Book 9. Sustainable Agriculture Research and Education (SARE) Program, College Park, MD.

Cosser, N.D., Gooding, M.J., Thompson, A.J., & Froudwilliams RJ (1997). Competitive ability and tolerance of organically grown wheat cultivars to natural weed infestations. *Annals of Applied Biology*, *130*, 523-535.

Davis, A.S. (2010). Cover-crop roller-crimper contributes to weed management in no-till soybean. *Weed Science*, *58*,300-309.

Didon, U.M.E. (2002). Variation between barley cultivars inearly response to weed competition. *Journal of Agronomy and Crop Science*, *188*, 176-184.

Enhellig, F.A. (1995). Alelopathy: Current status and future goals. In: K.M.M Inderjit Dakshini. & F.A. Enhellig (Eds.), *Allelopathy: Oganisms, processes and applications* (pp. 1-24). Washington, DC: American Chemical Society.

Feakin, S.D. (1973). *Pest Control in Groundnuts.* (3rd ed.). Center for Overseas Pest Research. London (pp. 197).

Finch, S. (1993). Integrated pest-management of the cabbage root fly and the carrot fly. *Crop Protection*, *12*, 423-430.

Gallet, C., & Pellissier, F. (1997). Phenolic compounds in natural solutions of a coniferous forest. *Journal of Chemical Ecology*, *23*, 2401-2412.

Goldberg, D.E. (1990). Components of resource competition in plant communities. In: J.B. Grace & D. Tilman (Eds.), *Perspectives on Plant Competition* (pp. 27–45). San Diego, CA: Academic Press.

Hansen, P. K., Kristensen, K., & Willas, J. (2008). A weed suppressive index for spring barley (*Hordeum vulgare*) varieties. *Weed Research,48*, 225-236.

Harrison, H. F., & Peterson, J. K. (1986). Allelopathic effects of sweetpotatoes (*Ipomoea batatas*) on yellow nutsedge (*Cyperus esculentus*) and alfafa (*Medicago sativa*). *Weed Science, 34*, 623-627.

Harrison, H. F., & Peterson, J. K. (1995). Sweet potato allelopathic substance inhibits growth of purple nutsedge (*Cyperus rotundus*). *Weed Technology, 9*, 277-280.

Inderjit, & Duke, S.O. (2003). Ecophysiological aspects of allelopathy. *Planta*, *217*, 529–539.

Inderjit, & Weston, L. A. (2003). Root exudates: An overview. In H. de Kroon & E.J.W. Visser, (Eds.). *Root ecology* (pp.235-255). Heidelberg: Springer-Verlag.

International Potato Center (2022). Facts and figures about sweetpotato (n.d.). https://cipotato.org/sweetpotato/ (Original work published 2017).

Kemble, J. M. (Ed.) (2011). *2012 Southeastern U.S. Vegetable Handbook*. Lincolnshire, IL: Vance Publishing Corp.

La Bonte, D.R., Harrison, H.F., & Motsenbocker, C.E. (1999). Sweetpotato clone tolerance to weed interference. *HortScience*, *34*, 229-232.

Levett, M. P. (1992). Effects of various hand-weeding programmes on yield and components of yield of sweetpotato (*Ipomoea batatas*) grown in the tropical lowlands of Papua New Guinea. *The Journal of Agricultural Science, 118*, 63-70.

Mason, H., Goonewardene L., & Spaner, D. (2008). Competitive traits and the stability of wheat cultivars in differing natural weed environments on the northern Canadian Prairies. *Journal of Agricultural Science*, *146*, 21–33.

Meyers, S.L., Arancibia, R.A., Shankle, M.W., Main, J., & Reddy R.K. (2014). *Sweet potato storage root initiation*. Mississippi State University Extension. Publication 2809:1-4.

Meyers, S. L., & Shankle, M.W. (2015). Interference of yellow nutsedge (*Cyperus esculentus*) in 'Beauregard' sweet potato (*Ipomoea batatas*). *Weed Technology, 29*, 854-860.

McKinlay, R.G., McCreath, M., & Armstrong, G. (1995, Nov. 6-8). *Undersowing cabbages with clover and its effect on the infestation levels of the cabbage root fly*. Proceedings Conference on Integrated control in field vegetable crops. Guitté, France.

Mirsky, S.B., Ryan, M.R., Teasdale, J.R., Curran, W.S., Reberg-Horton, S.C., Spargo, J.T., Wells, M.S., Keene, C.L., & Moyer, J.W. (2013). Overcoming weed management challenges in cover crop-based organic rotational no-till soybean production in the eastern United States. *Weed Technology, 27*,193-203.

Monks, D. W., Jennings, K. M., Meyers S. L., Smith, T. P., & Korres, N. E. (2019). Sweet Potato: Important Weeds and Sustainable Weed Management. In *Weed Control: Sustainability, Hazards, and Risks in Cropping Systems Worldwide* (1st ed., pp.581-596). CRC Press.

Morris, C., Grossl, P.R., & Call, C.A. (2009). Elemental Allelopathy: Processes, Progress, and Pitfalls. *Plant Ecology, 202* (1), 1-11.

MP44. *Recommended Chemicals for Weed and Brush Control* (2022). https://www.uaex.uada.edu/publications/mp-44.aspx

Mwendwa, J.M., Brown, W.B., Weidenhamer, J.D., Weston, P.A., Quinn, J.C., Wu, H., & Weston, L.A. (2020) Evaluation of commercial wheat cultivars for canopy architecture, early vigour, weed suppression, and yield. *Agronomy, 10*, 983.

Newcomer, D. T., Giraudo, L. J., & Banks, P. A. (1986). Soybean (*Glycine max*) Cultivar as a Factor of Weed Control in No-till Double-cropped Production Following Wheat. Athens, GA: Georgia Agricultural Experiment Station Research Report.

Okada, Y., Nishiguchi, M., Saito, A., Kimura, T., Mori, M., Hanada, K., Sakai, J.,Matsuda, Y., & Murata, T. (2002). Inheritance and stability of the virus-resistant gene in the progeny of transgenic sweetpotato. *Plant Breeding,121*, 249-253.

Peoples, M. B, Herridge, D. F, & Ladha, J. K. (1995). Biological nitrogen fixation: an efficient source of nitrogen for sustainable agricultural production? *Plant Soil*, *174*,3-28.

Price, A.J., & Wilcut, J.W. (2007). Response of ivyleaf mornninglory (*Ipomoea hederacea*) to neighboring plants and objects. *Weed Technolology, 21*,922-927.

Przepiorkowski, T., & Gorski, S.F. (1994). Influence of rye (*Secale cereale*) plant residues on germination and growth of three triazine-resistant and susceptible weeds. *Weed Technology, 8*,744-747.

Putnam, A.R. (1985). Allelopathic Research in Agriculture: Past Highlights and Potential. In: A.C. Thompson (Ed.), *The Chemistry of Allelopathy: Biochemical Interactions among Plants* (pp. 1-8). Washington DC: American Chemical Society.

Radosevich, S. R., Holt, J. S., & Ghersa, C. M. (2007). Ecology of weeds and invasive plants: relationship to agriculture and natural resource management (3rd ed,). *Weed ecology*.

Reberg-Horton, S.C., Grossman, J.M., Kornecki, T.S., Meijer, A.D., Price, A.J., Place G.T., & Webster, T.N. (2012). Utilizing cover crop mixtures to reduce tillage in organic systems in the southeastern USA. *Renewable Agriculture and Food Systems*, *27*, 41-48.

Rice, E.L. (1974). *Allelopathy*. Academic Press, New York.

Roberts, T.L., Ortel, C., Hoegenauer, K.L., Wright, H., & T. Durre. (2018). *Understanding cover crops*. University of Arkansas System Division of Agriculture Research and Extension. https://www.uaex.uada.edu/publications/pdf/FSA-2156.pdf

Schultheis, J.R., Walters, S.A., Adams, D.E., & Estes, E.A. (1999). In-row plant spacing and date of harvest of ‘Beauregard’ sweetpotato affect yield and return on investment. *HortScience ,34,*1220-1233.

Seavers, G.P., & Wright, K.J. (1997). Influence of crop growth habit and canopy development on weed suppression. In M.J. Gooding & P.R. Shewry, (Eds.), *Optimising Cereal Inputs: Its Scientific Basis Aspects of Applied Biology* (pp.361-366). Warwick, UK: Association of Applied Biologists.

Seem, J.E., Creamer, N.G., & Monks, D.W. (2003). Critical weed-free period for 'Beauregard' sweetpotato (*Ipomoea batatas*). *Weed Science, 17*, 686-695.

Smith, S., Jennings, K.M., Monks, D.W., Chaudhari S., Schultheis, J.R., & Reberg-Horton, C. (2020). Critical timing of Palmer amaranth (*Amaranthus palmeri*) control in sweetpotato. *Weed Technology*, *34* (4), 547-551.

Shen, S., Xu, G., Li, D., Clements, D. R., Jin, G., Liu, S., Yang, Y., Chen, A., Zhang, F., & Hisashi, K. N. (2017). Allelopathic Effects of Three Sweet Potato Cultivars (*Ipomoea batatas*) on the Invasive Plant *Mikania micrantha*. *Pakistan Journal of Biological Sciences*, *21*, 8-15.

Soni, B., Tseng, T.-M.P., & Yue, Z.M. (2019). Identification and Quantification of Allelochemicals from Selected Sweet Potato (*Ipomoea batatas* (L.) Lam.) Cultivars. *American Journal of Plant Sciences*, *10*, 2354-2365.

Sweet, R.D., Yip, C.P., & Sieczka, J.B. (1974). Crop varieties: Can they suppress weeds? *New York's Food and Life Science*, *7*, 3-5.

Teasdale, J.R., & Mohler, C.L. (1993). Light transmittance, soil temperature, and soil moisture under residue of hairy vetch and rye. *Agronomy Journal*, *85*,673-680.

Theunissen, J., & Schelling, G. (1996). Pest and disease management by intercropping: Suppression of thrips and rust in leek. *International Journal of Pest Management*, *42*, 227-234.

Trezzi, M.M., Balbinot Jr, A.A., Benin, G., Debastiani,, F., Patel, F., & Miotto Jr, E. (2013). Competitive ability of soybean cultivars with horseweed (*Conyza bonariensis*). *Planta Daninha*, *31*, 543-550.

USDA. United States Department of Agriculture (2015). *Vegetables and Pulses Outlook: Special Article. Commodity Highlight: Sweet Potatoes*. https://www.ers.usda.gov/webdocs/outlooks/39544/52774_vgs-355-sa1.pdf?v=6118

USDA-NASS. Department of Agriculture, National Agricultural Statistics Service (2022). Quickstats Data Portal. http://www.nass.usda.gov/Quick_Stats/

Vann, R.A., Reberg-Horton, S.C., Poffenbarger, H.J., Zinati, G.M., Moyer, J.B., & Mirsky, S.B. (2017). Starter fertilizer for managing cover crop-based organic corn. *Agronomy Journal*, *109*,1-9.

Wicks, G.A., Nordquist, P.T., Baenziger, P.S., Klein, R.N., Hammons, R.H., & Watkins J.E. (2004). Winter wheat cultivar characteristics affect annual weed suppression. *Weed Technology*, *18*, 988-998.

Wang, K., McSorley, R., Gallaher R. N., & Kokalis-Burelle, N. (2008). Cover crops and organic mulches for nematode, weed and plant health management. *Nematology, 10*, 231-242.

Worthington, M., & Reberg-Horton, C. (2013). Breeding cereal crops for enhanced weed suppression: Optimising allelopathy and competitive ability. *Journal of Chemical Ecology*, *39*, 213-231.

Wubanechi, S. (2014*). Effect of Planting Density on Growth and Yield of Sweet Potato* (*Ipomea batatas* (L.) Lam) Varieties in Habru District, Northern Ethiopia. [Master's Thesis, Harmaya University].

Xuan, T. D., Minh, T.N., Trung K.H., & Khanh, T. D. (2016). Allelopathic potential of sweet potato varieties to control weeds: *Imperata cylindrica, Bidens pilosa,* and *Ageratum conyzoides. Allelopathy Journal*, *38,* 41-54.

Zimdahl, R. L. (2007). *Fundamentals of weed science* (3rd ed.). Academic Press.

Allelopathic Potential and Competitive Traits of Sweetpotato Cultivars

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Abstract

Allelopathy and competition are components of plant-plant interactions, delimiting the level of interference. Understanding this interaction has practical applications in agriculture. Crop cultivars possessing high allelopathic ability and competitive traits are themselves tools for sustainable weed management, enabling reduced use of herbicides. Greenhouse and field experiments were conducted to assess the weed suppressive ability of selected sweetpotato (*Ipomoea batatas* L.) cultivars. The effect of nine cultivars on Palmer amaranth (*Amaranthus palmeri* S. Watson), junglerice (*Echinochloa colona* L.), and hemp sesbania (*Sesbania hederacea* P. Mill.) was first evaluated in the greenhouse. The experiment was set up in a completely randomized design with four replications and conducted twice. Sweetpotatoes were cultured in sand. The target weeds were seeded in pots filled with a 2:1 mix of field soil:potting mix and watered with 100-ml aliquot of sweetpotato root leachates once every 2 d. Weed height and shoot biomass were measured. ‘Heartogold’, ‘Centennial’, and ‘Stokes Purple’ were the most allelopathic cultivars. Junglerice was most inhibited by sweetpotato leachate. Nine cultivars were evaluated in the field. Experiments were conducted at Fayetteville and Kibler, Arkansas, USA, in a split-plot design, with weed infestation (broadleaf spp., grass spp., or weed-free) as whole plot and the cultivars as split-plot. Across locations, ‘Beauregard-14’ had the longest vines, whereas ‘Hatteras’ and ‘Heartogold’ had the tallest canopy. ‘Heartogold’ had the largest leaf area. This cultivar reduced weed biomass 2- to 4-fold in both locations. Yield was reduced by 53- and 72% with grass and broadleaf weeds across locations. ‘Beauregard-14’ and ‘Bayou Belle-6’were the high-yielding cultivars in Kibler and Fayetteville. The highest yielding cultivars were not the most weed suppressive but did not incur the highest yield loss from weed competition, indicating the ability to withstand weed interference.

Introduction

Sweetpotato (*Ipomea batatas* L.) belongs to the Convolvulaceae family and is the cultivated relative of the viny, wild, and weedy *Ipomoea* spp. The shoot architecture and prostrate growth habit of sweetpotato make this crop particularly susceptible to weed interference, especially before the vines form a closed canopy. The critical period for weed interference in sweetpotato is from 7 d to 56 d after transplanting (DAT); with the most critical time between 30 and 45 DAT (Levett, 1992). Yield losses due to weeds, particularly Palmer amaranth (*Amaranthus palmeri* S. Watson), be as high as 79% with 1 to 8 Palmer amaranth plants m^{-1} of row (Basinger et al., 2019) and 35% to 76% at 1 to 16 large crabgrass (*Digitaria sanguinalis* L.) plants m^{-1} of row. Herbicide options are limited in sweetpotato production. Only sethoxydim, clethodim, clomazone, fluazifop, *S*-metolachlor, and flumioxazin are registered (Monks et al., 2019). Only selective grass herbicides (clethodim and fluazifop) can be used for postemergence weed control; all other weeds need to be removed by repeated handweeding (Kemble, 2017). To alleviate the cost of handweeding, the row middles can be cultivated before the vines overlap. On average, 95% of growers perform inter-row cultivation three times before vines overlap (Haley and Curtis, 2006). Other practices include handweeding and between-row application of postemergence herbicides, which are performed by 62% and 19% of growers, respectively (Haley and Curtis, 2006).

The lack of herbicide options calls for supplemental practices that provide effective weed control. The development of cultivars with superior competitive ability against weeds could complement cultural and chemical control methods. The recognition of the role of crop competitiveness in weed suppression is not new and has been reviewed in studies including corn (*Zea mays* L.) (Sankula et al., 2004), cotton (*Gossypium hirsutum* L.) (Chandler and Meredith, 1983), wheat (*Triticum aestivum*) (Mason et al., 2007), spring barley (*Hordeum vulgare* L.) (Hansen et al. 2008), and soybeans (*Glycine max* L. Merr.) (Trezzi et al., 2013). In the last 15 yr, the role of crop competitiveness is becoming even more important considering the widespread occurrence, and continuing evolution of, herbicide-resistant weeds (Harker and O'Donovan, 2013). Cultivar competitiveness is reflected either as: (1) ‘weed suppressive ability’ or (2) ‘tolerance’ to weed infestation, or both (Hansen et al., 2008). The first is related to the ability of a cultivar to reduce the fitness of the surrounding weeds (Christensen, 1995). In this case, competitive cultivars reduce weed emergence, growth, or fecundity. The second outcome pertains to the ability of some cultivars to tolerate weed infestation and incur less yield loss than cultivars that are less tolerant to weed interference (Lemerle et al., 1996).

The traits contributing to crop advantage against weeds are related to morphological characteristics as being tall, rapid growth, canopy closure, and high leaf area index (Konesky et al., 1989; Balyan et al., 1991; Cudney et al., 1991). In wheat and barley, better weed suppression has been attributed to high leaf area index and wide leaf angle that promotes shading (Hoad et al., 2006; Hansen et al., 2008). In soybeans, indeterminate growth habit and faster canopy development are associated with competitive ability against weeds (Newcomer et al., 1986). Crop competitiveness could also be related to chemical interference among plants (allelopathy). Allelopathy was first described by Hans Molisch in 1937, referring to the effect of biochemical substances transferred from one plant to another. The utility of allelopathy as a viable component of weed management is well documented in crops including rice (Li et al., 2015), wheat (Dadkhah, 2015), canola (Dadkhah, 2015), and cotton (Ma et al., 2012). In sweetpotato, allelopathic metabolites have been found in stems, leaves, and root exudates (Xuan et al., 2016), which include caffeic acid, chlorogenic acid, coumarin, trans-cinnamic acid, and hydroxy cinnamic acid (Soni et al., 2019). Several sweetpotato cultivars, including ‘Heartogold’, produce high concentrations of allelochemicals that inhibit the growth of Palmer amaranth (Soni et al., 2019). In a screening of 48 sweetpotato cultivars, three (‘Yen 36’, ‘54’, and ‘615’) suppressed cogongrass (*Imperata cylindrica* L.) germination more than 90% (Xuan et al., 2016). A study of ten sweetpotato cultivars showed that ‘Heartogold’ and ‘529’ from Louisiana (USA) and Guatemala, respectively, had the highest concentration of allelochemicals and reduced Palmer amaranth biomass (39%) and height (≥80%) (Soni et al., 2019). In the same study, ‘Centennial’, ‘Morado’, and ‘Spokes Purple’ were classified as having intermediate allelopathic potential due to the high concentration of coumarin and caffeic acid but caused poor inhibition of Palmer amaranth biomass (≤26%). The composition and quantity of allelochemicals produced vary across cultivars; therefore, it takes great effort to find cultivars with high allelopathic potential and desirable agronomic traits. Ultimately, the differential weed suppression by sweetpotato genotypes reflects the total effect of genetic background (Xuan et al., 2016), weed-competitive morphology, the allelochemicals present, and the quantity of these compounds (Soni et al., 2019).

The objectives of this study were to (1) identify weed-suppressive sweetpotato cultivars on broadleaf and grass species, (2) determine the tolerance of sweetpotato cultivars to full-season weed interference, and (3) identify the crop traits contributing to its competitive advantage against weeds.

Materials and Methods

Assessment of allelopathic effect in the Greenhouse

A greenhouse study was conducted in 2020 at the Altheimer Laboratory, University of Arkansas, Fayetteville, USA (36° 5’55.213’’ N,94°10’43.038’’W). Nine sweetpotato cultivars (‘Heartogold’, ‘Centennial’, ‘Evangeline’, ‘Hatteras’, ‘Bayou Belle-2’, ‘Bayou Belle-6’, ‘Beauregard-14’, ‘Beauregard-63’, and ‘Stokes Purple’) were evaluated for allelopathic suppression of Palmer amaranth, junglerice, and hemp sesbania (*Sesbania herbacea* L.) over four weeks. The experimental design was completely randomized with four replications and was conducted twice.

Sweetpotato vines (15-cm, 6 pot^{-1}) were planted in 25-cm pots filled with 2.5 kg play sand and overlayed with 0.2 kg of commercial potting soil (Mycorrhizae®, Quebec, Canada). Each pot was placed in a plastic bucket (4.72 cm x 3.7 cm) and watered with 900 ml of tap water once every two days. The root leachates were collected and applied in 100-ml aliquots to target weeds. The control treatments received 100-ml of tap water. The target weeds were planted in 15-cm pots filled with 0.5 kg of silt loam soil (pH 6.7; with P, K, Ca, Mg, S, Na, Fe, Mn, Cu, and B contents of 84, 186, 1326, 273, 5.8, 6.4, 235, 106,4.0, 1.7, and 0.4 mg kg^{-1}, respectively). The field soil was mixed 2:1 with commercial potting medium. Four seedlings were kept per pot and heights were measured once weekly. Four weeks after planting, the plants were cut at the soil surface, oven-dried, and weighed. Biomass and height reduction were calculated as:

$$\text{Reduction (\%)} = \frac{(100 - (\text{height or biomass of receiver plant x}100))}{\text{height or biomass of control plant}}$$

where the control is the mean biomass of all plants in four control pots, and the biomass of receiver species was the mean of four plants per pot treated with sweetpotato leachates. Principal component analysis (PCA) and hierarchical clustering using Ward’s method were performed in JMP 16.1 (SAS Institute Inc., Cary, NC) to visualize the correlation among variables and group the cultivars based on the overall allelopathic potential.

Field experiment

Field experiments were conducted in Arkansas, USA in 2021, at the Vegetable Station (35°22’44.249’’ N, 94°13’59.506’’W), Kibler and at the Shult Agricultural Research and Extension Center (36°5’56.786’’ N, 94°10’43.9’’W), Fayetteville. The total rainfall during the growing season was 727 mm in Fayetteville and 731 mm in Kibler (Table 4). The soil in the Fayetteville site was silt loam with pH 7.1 and nutrient contents of P, K, Ca, Mg, S, Na, Fe, Mn, Zn, Cu, and B at 49, 103, 1073, 40, 7.1, 7.4, 88, 213, 2.2,1.3, and 0.4 mg kg^{-1}, respectively. In Kibler the soil was silt loam with pH 7.1 and nutrient contents of P, K, Ca, Mg, S, Na, Fe, Mn, Zn, Cu, and B at 110,101,799, 149, 6.1, 17.3, 229,72, 2.1, 1.0, and 0.4 mg kg^{-1}, respectively.

The split-plot experiment consisted of (1) weed species as whole plot (broadleaf spp., grass spp., or weed-free), and (2) sweetpotato cultivars as split-plot (‘Heartogold’, ‘Centennial’, ‘Evangeline’, ‘Hatteras’, ‘Bayou Belle-2’, ‘Bayou Belle-6’, ‘Beauregard-14’, ‘Beauregard-63’, and ‘Morado’). A weed-only plot was established as check in each whole plot. The whole plot size was two rows, each 0.9 m wide and 15 m long, which were then subdivided into split-plot consisting of one row, 0.9 m wide and 3.0 m long. One week prior to transplanting the slips, complete fertilizer (13-13-13) was applied at 227 kg ha^{-1}, and the field was bedded. Urea fertilizer (32-0-0) was applied at 45.5 kg ha^{-1} along the side of sweetpotato plants 8 wk after transplanting (WAT). Cuttings (20- to 30-cm long) were hand-transplanted on May 22, 2021, and June 17, 2021, in Fayetteville and Kibler, respectively. The slips were planted in a horizontal position with two nodes buried, 46 cm apart in the bed. Typically, sweetpotato cuttings are transplanted between mid-May and mid-June. Because of rainfall events, sweetpotato transplanting in Kibler was delayed by four weeks compared to Fayetteville. On the same day as sweetpotato transplanting, plots assigned to broadleaf spp. and grass spp. were broadcast-seeded with Palmer amaranth and junglerice, respectively, at a density of 20 seeds m^{-2}. In the weedy treatments, native weeds were allowed to grow unchecked. Broadleaf weed species were manually removed from grass plots and grasses were controlled in the broadleaf plots with a postemergence application of clethodim (Select Max®, Valent U.S.A. LLC Agricultural Products, Walnut Creek, CA) at 140 g ai ha^{-1} plus Crop Oil Concentrate (COC) at 0.25% v v^{-1}. Weed-free plots were hand-weeded every other week until 12 WAT.

Data were collected from the two inner plants of each plot. Weeds were counted by species at 5 and 7 WAT from 0.5 m^2 quadrat in each split-plot. The canopy height and length of the longest vine were measured at 5 and 7 WAT. Sweetpotato leaves were collected from 0.13 m^2 ground area 1 wk prior to harvest. Leaf area was measured using Li-cor Model 3100 leaf area meter (Li-cor Inc. Lincoln, Nebraska, USA) and then converted to leaf area index (LAI), as follows:

$$\mathrm{LAI} = \frac{\text{Leaf area } (\mathrm{m}^2)}{\text{Ground cover } (\mathrm{m}^2)}$$

Shoot biomass of weeds was collected from 0.5 m^2 per split-plot2 wk before harvest. Samples were then placed in a forced-air drier for 120 h at 80 °C. Dry biomass was recorded. Sweetpotato storage roots were harvested 153 and 141 d after transplanting (DAT) in Fayetteville and Kibler, respectively. Roots were graded into jumbo (8.9 cm in diameter), no. 1 (≥4.4 cm but <8.9 cm), canner (≥2.5 cm but <4.4 cm), and cull (misshapen roots) (USDA, 2005), then weighed by grade. Total marketable yield was calculated as the sum of jumbo, no. 1, and canner grades.

The phytosociological parameters relative frequency (RF), relative density (RD), relative abundance (RAb), and importance value index (IVI) of broadleaf spp. and grass spp. treatments were assessed with the following equations (Werle et al., 2021):

$$\text{Frequency (F)} = \frac{\text{number of samplings in which the species were found}}{\text{total number of samplings}}$$

$$\text{Relative frequency (RF)} = \frac{\text{frequency x 100}}{\text{total species frequency}}$$

$$\text{Density (D)} = \frac{\text{number of plants for the species}}{0.25\ \text{m}^2}$$

$$\text{Relative density (RD)} = \frac{\text{density of species x 100}}{\text{total species density}}$$

$$\text{Abundance (Ab)} = \frac{\text{number of plants found for the species}}{\text{total number of samplings in which the species was found}}$$

$$\text{Relative abundance (RAb)} = \frac{\text{abundance x 100}}{\text{total species abundance}}$$

$$\text{Importance value index (IVI)} = \frac{\text{RF x RD x RAb}}{\text{total species abundance}}$$

where RD, RF, and RAb are the number of species, their distribution, and abundance relative to other species in the sampled area, respectively. IVI indicates the most important species in the study area. Total frequency, density, and abundance were obtained from the sum of the relative number of each of the parameters.

In this study, the whole plot effect of weed species, the split-plot effect of sweetpotato cultivars, and the interaction between weed species and cultivars were considered fixed effects. The experiments were analyzed by location because of significant treatment by location interaction. The replications within location and the error associated with the whole plot and residual (split-plot) were considered as random effects. The Restricted Maximum Likelihood (REML) was used to estimate variance components. This experiment can be described with the following linear model:

$$Y_{ijk} = \mu + Bl_i + A_j + \eta_{ij} + B_k + AB_{jk} + \varepsilon_{ijk}$$

where Y_{ijk} is the response variable, Bl_i is the random effect of blocks, A_j is the fixed effect of weed species (whole plot) on the response variable, η_{ij} is the whole plot error, B_k is the fixed effect of sweetpotato cultivars (split-plot) on the response variable, AB_{jk} is the fixed effect of the interaction between weed species and cultivars, and ε_{ijk} is the split-plot error. Bl_i, η_{ij}, and ε_{ijk} are assumed to be independent of one another. Data were analyzed in JMP® Pro 16.1 (SAS Institute Inc., Cary, NC), and mean values were separated using Student's *t*-test. Significant differences between the means were determined at 5% level of probability ($p \leq 0.05$).

Results

Biomass and height reduction of weed species in the greenhouse

In the greenhouse, sweetpotato root leachates reduced weed growth in terms of height and shoot biomass. Weeds responded differently to root leachate of sweetpotato cultivars and the inhibitory effects on weeds declined with time, except on Palmer amaranth (Tables 1,2). Junglerice was the most stunted regardless of sweetpotato cultivar. The maximum height reduction occurred in the first week (27%) and decreased to 16, 11, and 10% in the second, third, and fourth weeks, respectively. Root leachates from ‘Heartogold’, ‘Centennial’, ‘Evangeline’, and ‘Hatteras’ stunted junglerice the most. Height reduction of hemp sesbania was minimal at 13% in the first week and declining to 5% in the fourth week. Although hemp sesbania stunting did not differ between cultivars, ‘Beauregard-14’, ‘Beauregard-63’, ‘Evangeline’ and ‘Centennial’ had the highest observable effect on hemp sesbania. Palmer amaranth was stunted the most by ‘Bayou Belle-6’, ‘Centennial’ and ‘Stokes Purple’ but not more than 10% and was the least affected by sweetpotato cultivar leachates compared to the other species.

Junglerice biomass was most reduced by root exudates of sweetpotato cultivars compared to hemp sesbania and Palmer amaranth (Table 3). Biomass reduction of hemp sesbania ranged from 2 to 19%. Centennial’ (19%) and ‘Stokes Purple’ (14%) caused the highest biomass reduction of hemp sesbania, but little difference was observed with other cultivars. ‘Stokes Purple’ and ‘Heartogold’ caused the highest numerical reduction of junglerice biomass. Palmer amaranth biomass was reduced only up to 10% and the reduction did not differ across cultivars.

Allelopathic categories of sweetpotato cultivars

Three dendrograms were created to categorize the sweetpotato cultivars based on allelopathic effect on hemp sesbania, Palmer amaranth, and junglerice using height and biomass reduction data (Figure 1). ‘Centennial’, ‘Beauregard-14’, ‘Beauregard-63’, and ‘Evangeline’ composed the cluster that caused the greatest height reduction of hemp sesbania. ‘Heartogold’ and 'Bayou-Belle-6' caused moderate height reduction and high biomass reduction of hemp sesbania. For Palmer amaranth, 'Centennial', 'Stokes Purple', and 'Bayou Belle-6', fell in the high height-reduction cluster, whereas 'Evangeline' caused the highest biomass reduction. For junglerice, 'Heartogold' and 'Centennial' caused the greatest height reduction and 'Stokes Purple' caused the highest biomass reduction.

Weed composition in the field

Weed composition differed between the two locations. The weed community was composed of eight broadleaf and nine grass species in Fayetteville (Table 5). The Kibler site had three broadleaf and seven grass species (Table 6). The relative weed frequency (RF), density (RD), abundance (RAb), and overall importance value index (IVI) did not differ between sweetpotato cultivars at 5 and 7 WAT.

Among the broadleaf species in Fayetteville, carpetweed (*Mollugo verticillata* L.) and Palmer amaranth had the highest IVI, at 105 and 99%, respectively, 5 WAT and 96 and 120%, respectively, 7 WAT (Table 5). Carpetweed was the most abundant (RD=43 %) 5 WAT, but Palmer amaranth became most abundant (RD=46%) 7 WAT. Broadleaf signalgrass [*Urochloa platyphylla* (Munro ex C. Wright) R.D. Webster] and junglerice were the most predominant grass species in Fayetteville. Broadleaf signalgrass had the highest RF, RD, RAb at 5 and 7 WAT, and reached an IVI value of 93% and 144% at 5 and 7 WAT, respectively. Junglerice had an IVI value of 60% and 64% at 5 and 7 WAT, respectively, indicating similar or even greater importance than broadleaf signalgrass.

Palmer amaranth had the highest RF, RD, RAb, and IVI % among broadleaf weeds at 5 and 7 WAT in Kibler (Table 6). Overall, the relative densities of carpetweed and tall morningglory (*Ipomoea purpurea* L.) were low (RD<5%), while Palmer amaranth had RD values of 95% and 96% at 5 and 7 WAT, respectively. Junglerice was the most predominant grass species in Kibler, with an IVI of 158% and 156% at 5 and 7 WAT, respectively. The RF, RD, and RAbR values of junglerice remained high (42, 62, and 52%, respectively) at 7 WAT. Large crabgrass was also a dominant grass species in Kibler, showing increasing importance with time (IVI =71% and 96% at 5 and 7 WAT, respectively). At 7 WAT, large crabgrass had RF, RD, and RAb values of 33, 31, and 32%, respectively.

Effect of sweetpotato on weed biomass

The cultivar by weed species interaction ($p = 0.0382$) was significant for dry biomass in Fayetteville (Figure 2). The cultivar by weed species interaction ($p = 0.3564$) was not significant in Kibler, but sweetpotato cultivars significantly reduced weed biomass ($p = 0.0459$) regardless of species. Grass weed biomass in weed-only plots in Fayetteville was 593 g m^{-2}. 'Heartogold' had the lowest grass weed biomass (166 g m^{-2}). The lowest and highest biomass of broadleaf species in Fayetteville was found in plots with 'Heartogold' (693 g m^{-2}) and Hatteras (3,683 g m^{-2}), respectively. In Kibler, the lowest grass spp. biomass (886 g m^{-2}) was recorded in plots with 'Beauregard-14', nearly 50% lower than the weed biomass in weed-only plots (1697 g m^{-2}). 'Bayou Belle-6' and 'Heartogold' significantly reduced broadleaf spp. biomass to about 40% less biomass than the weedy check.

Sweetpotato canopy height, vine length, and leaf area

The interaction effect of cultivar and weed species on vine length and canopy height of sweetpotato was not significant in both locations, but the cultivars differed significantly ($p < 0.05$) in these traits regardless of the weed species in competition at both evaluation times (Figures 3,4). The sweetpotato cultivars also differed in leaf area in both locations ($p = 0.0001$) and weed species ($p = 0.0181$) in both locations. The vine length and canopy height of sweetpotato cultivars were similar when growing weed-free. These traits also did not differ between cultivars when grown in competition with weeds (broadleaf or grasses). However, regardless of cultivar, sweetpotato vine and leaves were shorter when growing with weeds compared to growing weed-free. ‘Beauregard-14’ and ‘Beauregard-63’ had the longest vines in Fayetteville at 5 WAT, while ‘Beauregard-14’ and ‘Morado’ had the longest vines in Kibler (Figure 3). ‘Beauregard-14’ and ‘Beauregard-63’ remained the most viney in both locations at 7 WAT, although they were no longer differentiated from ‘Bayou Belle-6’ in Fayetteville and were also similar to ‘Morado’ in Kibler. At 5 WAT ‘Hatteras’, ‘Heartogold’, and ‘Centennial’ had the tallest canopy in Fayetteville (18-19 cm) and in Kibler (21-22 cm) (Figure 4). At 7 WAT, ‘Heartogold’ had the tallest canopy in Fayetteville (23 cm) and in Kibler (33 cm) .

LAI was roughly 50% greater when cultivars were grown in weed-free conditions compared to plots with weeds in both locations. Averaged across cultivars, LAI in weed-free plots was approximately 2 and 1.7 in Fayetteville and Kibler, respectively (Figure 5). This was measured from a ground area of 0.13 m^2. In Fayetteville, LAI across cultivars was reduced to 1.3 and 1 in plots with grasses and broadleaf weeds, respectively. In Kibler, LAI averaged 0.9 in broadleaf and grass plots. Cultivar ‘Heartogold’ had the greatest LAI (2.8) in Fayetteville (Figure 6). The greatest LAI in Kibler was also observed with ‘Heartogold’ (1.7), which was similar to that of ‘Centennial’ (1.4).

Sweetpotato yield by grade and yield loss

The interaction effect of weed species and cultivars on sweetpotato yield was not significant in Fayetteville and Kibler ($p > 0.05$); therefore, yield was averaged across cultivars within weedy treatments, and across weed species within cultivar treatments. Sweetpotato yield differed across cultivars and between weedibg treatments in both locations.

Jumbo, no. 1, canner, and cull yields of the weed-free plots were 35,090; 29,500; 3,822; and 990 kg ha^{-1} in Fayetteville and 34,396; 34,908; 7,114; and 4,450 kg ha^{-1} in Kibler, respectively, averaged across cultivars (Table 7). The greatest yield reduction due to weed interference was observed in jumbo sweetpotato roots in both locations. In Fayetteville, jumbo and no.1 yield decreased to 5,019 and 10,217 kg ha^{-1} under broadleaf and 7,050 and 19,041 kg ha^{-1} with grass infestation, respectively. In Kibler, jumbo and no. 1 yield decreased to 9,630 and 13,612 kg ha^{-1} and 12,041 and 16,123 kg ha^{-1} under broadleaf and grass infestation, respectively. In Fayetteville, canner yield was reduced to 5,844 kg ha^{-1} with grass infestation and 4,120 kg ha^{-1} under broadleaf weed infestation, respectively. Similarly, canner yield in Kibler was reduced to 5,169 and 3,450 kg ha^{-1} with grass and broadleaf infestation, respectively.

The greatest jumbo yield was obtained with 'Morado' (40,083 kg ha^{-1}) in Fayetteville, and with Bayou-Belle-6 (32,597 kg ha^{-1}) in Kibler (Table 8). No.1 yield was greatest with 'Bayou Belle-6' (28,563 kg ha^{-1}) in Fayetteville and Kibler (32,246 kg ha^{-1}). 'Heartogold' had the greatest canner yield (7,406 kg ha^{-1}) in Fayetteville, followed by 'Centennial' (6,961 kg ha^{-1}), 'Beauregard-14' (6,541 kg ha^{-1}), and 'Hatteras' (6,521 kg ha^{-1}), whereas 'Bayou Belle-6' had the highest canner yield in Kibler (14,076 kg ha^{-1}).

Averaged across weedy and weed-free treatments, the highest yielding cultivars in Fayetteville were 'Bayou Belle-6' (48,658 kg ha^{-1}), 'Morado' (48,423 kg ha^{-1}), 'Beauregard-14' (45,165 kg ha^{-1}), and 'Hatteras' (40,478 kg ha^{-1}) (Table 8). 'Bayou Belle-6' (78,919 kg ha^{-1}), 'Beauregard-14' (63,815 kg ha^{-1}), and 'Bayou Belle-2' (53,079 kg ha^{-1}) yielding the most in Kibler. 'Evangeline' showed the lowest yield at both locations. Overall, total sweetpotato yield was reduced by 65 and 56% in plots with broadleaf and grass species, respectively, compared to weed-free plots (76,418 kg ha^{-1}) in Kibler (Table 5). A similar response was observed in

Fayetteville, and yield was reduced by 72 and 53% broadleaf and grass species, respectively, compared to weed-free plots (68,412 kg ha^{-1}).

Discussion

The use of weed-suppressive cultivars is gaining attention in systems where herbicide use is restricted, herbicide options are few, or in organic farms where using conventional herbicides is not allowed. Commercially desirable cultivars are those that possess enhanced weed suppressive ability coupled with superior agronomic traits such as high yield potential (Gealy and Yan, 2012). For sweetpotatoes, commercial success eventually hinges on consumer preference for eating quality. In the field, plant-plant interactions are trigged by complex chemical (allelopathy) and physical (competition) mechanisms. Competition is the consequence of plants using a limited supply of the same resources, whereas allelopathy is the inhibitory effect of chemicals released by one plant to neighboring plants (Molisch, 1937). Allelopathy and competition occur simultaneously in the field and the observable weed suppression is the total effect of these two components (Olofsdotter et al., 2002). The present study provides insight on the potential of using weed-suppressive sweetpotato cultivars for improved weed control.

Allelopathic potential is cultivar- and weed-specific. The greenhouse experiments demonstrated this. Weed inhibition by allelochemicals decline with plant size and age. In fact, allelopathic effect is most apparent in terms of reduction of weed germination and seedling growth (Xuan et al. 2012; Xuan et al. 2016; Shen et al. 2018). In terms of seedling growth inhibition, allelopathic sweetpotato cultivars were effective only on junglerice while hemp sesbania and Palmer amaranth seedlings had minimum response. Nevertheless, junglerice is a major grass weed in the majority of crops, including sweetpotato. Reducing grass growth significantly improves the efficacy of herbicides in conventional production and improves weed control in organic production. In other studies, it has been documented that allelopathic ability could be more consistent within species of the same family. For instance, the correlation between allelopathic potential of rice against barnyardgrass [*Echinochloa crus-galli* (L.) P. Beauv.] and giant arrowhead [*Sagittaria montevidensis* var. spongiosa (Engelm.) B. Boivin] was 0.58, while that of grassy arrowhead *(Sagittaria graminea* Michx.) and water plantain (*Alisma plantagoaquatica* L.) was 0.93 (Seal and Pratley, 2010). Therefore, we can expect that the allelopathic sweetpotato cultivars that are highly allelopathic to junglerice would also be highly inhibitory to other grass weed species of similar seed size such as barnyardgrass and large crabgrass. Allelopathic compounds produced by various sweetpotato cultivars differ in quality and concentration (Soni et al., 2019). Sweetpotato contains plant growth inhibitors like coumarin, caffeic acid, and trans-cinnamic acid (Chon et al., 2005). All ten cultivars analyzed by Chon et al. (2005) produced chlorogenic and caffeic acid, but only a few cultivars produced hydroxycinnamic acid, trans-cinnamic acid, and coumarin. In the same study, ‘Heartogold’ and ‘529’ were classified as highly allelopathic and had higher amounts of total allelochemicals, particularly chlorogenic acid, and trans-cinnamic. ‘Centennial’ and ‘Stokes Purple’, on the other hand, showed intermediate allelopathic potential. In these cultivars, a high concentration of coumarin and caffeic acid was observed (Soni et al., 2019). In our study, ‘Heartogold’, ‘Centennial’, and ‘Stokes Purple’ inhibited all the three weed species to some extent, with the highest inhibition observed on junglerice.

The weed suppressive ability of ‘Heartogold’ was also observed in the field and was consistent across locations. The inhibitory potential of this cultivar was also reported in previous studies showing 80% growth inhibition of Palmer amaranth seedlings (Soni et al., 2019).

‘Centennial’, another potentially allelopathic cultivar in our study, was among the most effective cultivars in reducing weed biomass in the field. Although these data suggest that the allelopathic potential of ‘Heartogold’ and ‘Centennial’ is advantageous against weeds, allelopathy alone cannot account for the total weed suppression observed in the field. In our field trials, sweetpotato cultivars differ widely in morphological characteristics and are therefore expected to vary in their competitive ability with weeds. For instance, ‘Heartogold’, which reduced weed biomass the most in both locations, had the greatest leaf area and canopy height among the cultivars, but had shorter vines than most cultivars. Conversely, ‘Beaureagard-14’ and ‘Beauregard-63’ had the longest vines, but this characteristic had little effect on weed biomass reduction. This means that having longer vines is not as important as having large leaves and tall canopy in being able to suppress weed growth. In other crops, especially winter cereals, taller cultivars are better tolerators of weed pressure and better suppressors of weed biomass (Challaiah et al., 1986, Vandeleur and Gill, 2004). In some studies, allelopathy explained about 20% the total weed suppression ability observed in wheat (Bertholdsson, 2010), 34% in rice (Olofsdotter et al., 1999), and 58% in barley (Bertholdsson, 2010). This means that the larger component of interference is generally crop competitive ability. The selection and development of future potato cultivars should include fast growth, high leaf area index, and early-season canopy closure for weed suppression (Colquhoun et al., 2009). In our study it was noticeable that better weed suppression was achieved with cultivars that showed high allelopathic ability in the greenhouse and favorable morphological characteristics such as high leaf area index and tall canopy.

The performance of sweetpotato cultivars was similarly affected by the type of weed species present in the field. The sweetpotato leaf area, vine length, and canopy height were reduced similarly by broadleaf and grass weeds. In general, the degree of interference varies according to the species composing a weed community (Clarke, 1971). This study did not control for variation in the natural weed population nor considered the individual weed species present. Instead, a mixture of broadleaf or grass weed population was used to represent what growers would typically find in their fields. Dominant weeds within the Poaceae family in Kibler and Fayetteville were large crabgrass, junglerice, and broadleaf signalgrass. These species represent some of the common grasses that infest sweetpotatoes (Monks et al., 2019). Broadleaf weeds included Palmer amaranth, annual morningglories, and carpetweed, known to be troublesome in sweetpotato fields (Monks et al., 2019). According to Basinger et al. 2019, an individual plant of either Palmer amaranth or large crabgrass per meter of row can reduce sweetpotato yield by 50% and 35%, respectively, and the maximum yield loss due to weed density is 87% for Palmer amaranth and 83% for large crabgrass (Meyers et al., 2010). This occurs in part because of plant architecture and the ability to intercept light. In general, sweetpotato canopy reaches less than 0.5 m tall. In our experiments the canopy of most sweetpotato cultivars was less than 40 cm tall. Conversely, roughly 80% of the leaves of Palmer amaranth plants are positioned about 1 m above the ground (Meyers et al., 2010, Monks et al., 2019). The fact that sweetpotato canopy is shorter than most weeds means that it is shaded by the majority of weed species, resulting in less photosynthetic activity and reduced yield. Although grasses that emerge later are vulnerable to shading by the sweetpotato canopy, in our study, broadleaf signalgrass and junglerice exceeded the height of sweetpotato canopy throughout the growing season. This indicates ample time for weeds to emerge grow before the crop canopy approaches 100% ground copy. For several cultivars, full canopy closure was not attained at all, as indicated by LAI values less than 1.

Loss of jumbo and no. 1 yields was the most significant contributor to overall marketable yield reduction in weedy conditions, especially with broadleaf weeds. On average, weed interference reduced up to 85% of jumbo yield and up to 65% of no. 1 yield. Other studies predicted yield loss of jumbo and no.1 roots to be 30 to 94%, respectively for Palmer amaranth densities of 0.5 to 6.5 plants m^{-1} (Meyers et al., 2010). Canner grade roots, which are generally more variable and less valuable than other grades, were the least affected by weed interference in this study. Overall, the highly allelopathic cultivars in the greenhouse, including ‘Centennial’ and ‘Heartogold’, were significantly lower yielding in the field. It is possible that high production of allelopathic compounds had diverted substantial carbon resources from storage roots. After all, allelopathy is a protection mechanism, and some protection mechanisms have trade-offs manifested in various ways such as reduced yield (McCall and Fordyce, 2010). Additionally, the autotoxicity of plants producing allelochemicals should not be ignored. The inhibitory effect of root exudates on the plant itself has been documented in cucumber (*Cucumis sativus* L.), where photosynthesis process, transpiration, and stomatal functions were affected by its own root exudates (Yu et al., 2003). Other species including wheat and annual sowthistle (*Sonchus oleraceus* L.) produce allelochemicals that can be both phytotoxic to other species and autotoxic (Wu et al., 2007, Gomaa et al., 2014). Some derivates of benzoic and cinnamic acids, which were identified in root exudates of ‘Heartogold’, have been identified as autotoxins (Yu and Matsui, 1994).

The ability of a crop to suppress weeds and maintain yield potential under weed pressure can also be derived from different mechanisms of crop competitiveness (Lemerle et al., 2001), and may or may not be correlated (Jordan, 1993). For example, the root exudates of ‘Beauregard-14’ and ‘Bayou Belle-6’ did not affect weed growth in the greenhouse experiment and these cultivars caused little reduction in weed biomass in the field. The inferior weed suppression by these two cultivars in the field could be further attributed to the smaller leaf area and shorter canopy than that of most cultivars. Interestingly, these two cultivars were the highest yielding, with or without weed competition. These two cultivars appeared to be tolerant to weed competition, able to maintain its yield potential under weed pressure. Such trait is highly desirable.

Conclusions

Some sweetpotato cultivars including ‘Heartogold’, ‘Centennial’, and ‘Stokes purple’ are allelopathic. Junglerice seedlings are generally more affected by root leachates of these cultivars than the broadleaf species tested. Weed species differ in susceptibility to sweetpotato allelopathy, as is commonly known about allelopathic interactions. The allelopathic effects decrease with increasing plant size (or age). Cultivars with high allelopathic activity and competitive morphological characteristics cause higher and longer-lasting weed suppression. ‘Heartogold’ is strongly weed suppressive in the field regardless of weed species. This cultivar possesses superior plant architecture for weed suppression. Tall canopy and large leaf area contribute to weed suppression by this cultivar. Being viney is not important for weed suppression. ‘Beauregard-14’ and ‘Bayou Belle-6’ have superior yield performance in the absence of weeds and able to maintain their yield potential under weed pressure, despite its poor weed suppressive ability, suggesting a superior tolerance to weed competition. Effort to identify traits that can be used to improve cultivar competitiveness, yield potential, and desirable end-use characteristics must continue.

References

Asaduzzaman, M. D., Luckett, D. J., Cowley, R. B., An, M., Pratley, J. E., and Lemerle, D. (2014). Canola cultivar performance in weed-infested field plots confirms allelopathy ranking from in vitro testing. *Biocontrol Sci. Technol*. 24, 1394-1411.

Balyan, R. S., Malik, R. K., Panwar, R. S., and Singh, S. (1991). Competitive ability of winter wheat cultivars with wild oat (*Avena ludoviciana*). *Weed Sci*. 39, 154-158.

Basinger, N. T., Jennings, K. M., Monks, D. W., Jordan, D. L., Everman, W. J., Hestir, E. L., Waldschmidt, M. D., Smith, S. C., and Brownie, C. (2019). Interspecific and intraspecific interference of Palmer amaranth (Amaranthus palmeri) and large crabgrass (*Digitaria sanguinalis*) in sweetpotato. *Weed Sci*. 67: 426–432.

Bertholdsson, N.O. (2010). Breeding for spring wheat for improved allelopathic potential. *Weed Res*. 50, 49–57.

La Bonte, D. R., Harrison, H.F., and Motsenbocker, C.E. (1999). Sweetpotato Clone Tolerance to Weed Interference. *HortScience* 34, 229-232.

Chandler, J. M., and Meredith, W. R. Jr. (1983). Yields of three cotton (*Gossypium hirsutum*) cultivars as influenced by spurred anoda (Anoda cristata) competition. *Weed Sci*. 31, 303-307.

Christensen, S. (1995). Weed suppression ability of spring barley varieties. *Weed Res*. 35, 241–247.

Chon, S. U., and Boo, H. O. (2005). Difference in Allelopathic Potential as Influenced by root Periderm Colour of Sweet Potato (Ipomoea batatas). *J. Agron. Crop Sci.* 191, 75-80.

Clarke, G.L. (1971). Elementos de Ecologia. Omega, Barcelona. Pp.534.

Colquhoun, J. B., Konieczka, C. M., and Rittmeyer, R. A. (2009). Ability of Potato Cultivars to Tolerate and Suppress Weeds. *Weed Technol*. 23, 287-291.

Cudney, D. W., Jordan, L. S., and Hall, A. E. (1991). Effect of wild oat (*Avena fatua*) infestations on light interception and growth rate of wheat (*Triticum aestivum*). *Weed Sci*. 39, 175-179.

Dadkhah, A. (2015). Allelopathic Potential of Canola and Wheat to Control Weeds in Soybean (*Glycine max*). *Russ. Agric. Sci.* 41, 111–114.

Gealy, D. R., and Yan, W. (2012). Weed suppression potential of 'Rondo' and other indica rice germplasm lines. *Weed Technol*. 26:524–527.

Gomaa, N. H., Hassan, M. O., Fahmy, G. M., González L., Hammouda, O., and Atteya, A. M. (2014). Allelopathic effects of Sonchus oleraceus L. on the germination and seedling growth of crop and weed species. *Acta Bot. Bras.* 28, 408– 416.

Hansen, P. K., Kristensen, K., and Willas, J. (2008). A weed suppressive index for spring barley (Hordeum vulgare) varieties. *Weed Res*. 48, 225–236.

Harker, N. K., and O'Donovan, T. J. (2013). Recent Weed Control, Weed Management, and Integrated Weed Management. *Weed Technol*. 27, 1-11.

Jordan, N. (1993). Prospects for weed control through crop interference. *Ecol. Appl.* 3, 84–91.

Kemble, J. M. (2017). *Southeastern U.S. Vegetable Crop Handbook*. 18th ed. Lenexa, KS: Farm Journal Media.

Konesky, D.W., Siddiqi, M. Y., Glass, A. D. M., and Hsiao, A. L. (1989). Wild oat and barley interactions: varietal differences in competitiveness in relation to phosphorus supply. *Can J. Bot*. 67, 3366-3371.

Lemerle, D., Verbeek, B., Cousens R. D., and Coombes, N. E. (1996). The potential for selecting wheat varieties strongly competitive against weeds. *Weed Res*. 36, 505–513.

Lemerle, D., Blackshaw, R. E., Smith, A. B., Potter, T. D., and Marcroft, S.T. (2001). Comparative survey of weeds surviving in triazine-tolerant and conventional canola crops in south-eastern Australia. *Plant Prot. Quarterly* 16, 37–40.

Levett, M. P. (1992). Effects of various hand-weeding programmes on yield and components of yield of sweetpotato (*Ipomoea batatas*) grown in the tropical lowlands of Papua New Guinea. *J. Agric. Sci.* 118, 63–70.

Li, J. Y., Guo, X. K., Zhang, Q., Liu, C. H., Lin, Z. H., Yu, Z. M., Wu, H., and He, H.B. (2015). A novel screening method for rice allelopathic potential: the inhibitory-circle method. *Weed Res*. 55, 441-448.

Ma, Y., Lang, M., Dong, S., Shui, J., and Zhao, J. (2012). Screening of Some Cotton Varieties for Allelopathic Potential on Clover Broomrape Germination. *Agron. J.* 104, 569–574.

Mason, H. E., Navabi, A., Frick, B., O'Donovan, and J. Snaper, D. (2007). Cultivar and seeding rate effects on competitive ability if spring cereals are grown under organic management in Northern Canada. *Agron. J.* 90,1199-1207.

Meyers, S. L., Jennings, K. M., Schultheis, J. R., and Monks, D. W. (2010). Interference of Palmer amaranth (*Amaranthus palmeri*) in sweet potato. *Weed Sci*. 58,119–203

McCall, A. C., and Fordyce, J. A. (2010). Can optimal defence theory be used to predict the distribution of plant chemical defences? *J. Ecol*. 98, 985-992.

Molisch, H. (1937). Der einfluss einer pflanze auf der ander – Allelopathie. Jena, Verlag von Gustav Fischer.

Monks, D. W., Jennings, K. M., Meyers S. L., Smith, T. P., and Korres, N. E. (2019). "Sweet Potato: Important Weeds and Sustainable Weed Management", in Weed Control: Sustainability, Hazards, and Risks in Cropping Systems Worldwide, eds. N.E. Korres, N. Roma-Burgos, and S. O. Duke (CRC Press), 581-596.

Newcomer, D. T., Giraudo, L. J., and Banks, P. A. (1986). Soybean (*Glycine max*) Cultivar as a Factor of Weed Control in No-till Double-cropped Production Following Wheat. Athens, GA: Georgia Agricultural Experiment Station Research Report. Pp. 16.

Olofsdotter, M., Navarez, D., Rebulanan, M., and Streibig, J. C. (1999). Weed-suppressing rice cultivars ± does allelopathy play a role? *Weed Res*. 39, 441-454.

Olofsdotter, M., Jensen, L. B., and Courtois, B. (2002). Improving crop competitive ability using allelopathy–an example from rice. *Plant Breed*. 121,1–9.

Yu, J. Q., Ye, S. F., Zhang, M. F., and Hu, W. H. (2003). Effects of root exudates and aqueous root extracts of cucumber (*Cucumis sativus*) and allelochemicals, on photosynthesis and antioxidant enzymes in cucumber. *Biochem. Syst. Ecol.* 31, 129-139.

Sankula, S., VanGessel, M. M., and Mulford, R. R. (2004). Corn leaf architecture as a tool for weed management in two production systems. *Weed Sci*. 52, 1026-1033.

Seal, A.N., and Pratley, J.E. (2010). The specificity of allelopathy in rice (*Oryza sativa*). *Weed Res*. 50:303–311.

Shen, S., Xu, G., Li, D., Clements, D.R., Jin, G., Liu, S., Yang, Y., Chen, A., Zhang, F., and Hisashi, K.N. (2018). Allelopathic Effects of Three Sweet Potato Cultivars (*Ipomoea batatas*) on the Invasive Plant Mikania micrantha. Pakistan Journal of Biological Sciences 21, 8-15.

Soni, B., Tseng, T. M. P., and Yue, Z. M. (2019). Identification and Quantification of Allelochemicals from Selected Sweet Potato (*Ipomoea batatas* (L.) Lam.) Cultivars. *Am. J. Plant Sci*. 10 2354-2365.

Trezzi, M. M., Balbinot, A. A., Benin, Jr. G., Bastiani, F., Patel, F., and Miotto E. (2013). Competitive ability of soybean cultivars with horseweed (*Conyza bonariensis*). *Planta daninha* 32 (3).

Vandeleur, R. K., and Gill, G.S. (2004). The impact of plant breeding on the grain yield and competitive ability of wheat in Australia. *Aust. J. Agric. Res.* 55, 855–861.

Werle, I. S., Zanon A. J., Streck, N. A., Schaedler, C. E., Barbieri, G. F., and Ulguim, A. (2021). Technology Levels in Cassava Cultivation Alter Phytosociology of Weeds. *HortScience* 56, 787-794.

Wu, H., Pratley, J. E., Lemerle, D., An, M., and Liu, D. L. (2007). Autotoxicity of wheat (*Triticum aestivum* L.) as determined by laboratory bioassays. *Plant Soil* 296, 85-93

Yu, J. Q., and Matsui, Y. (1994). Phytotoxic substances in the root exudates of *Cucumis sativus* L. *J. Chem. Ecol*. 20,21-31.

[USDA] United States Department of Agriculture (2005). *United States Standards for Grades of Sweetpotatoes*. https://www.ams.usda.gov/sites/default/files/media/Sweetpotato_Standard%5B1%5D.pdf [03 December 03 2021].

Xuan, T.D., Toyama, T., Khanh, T.D., Tawata, S., and Nakagoshi, N. (2012). Allelopathic interference of sweet potato with cogongrass and relevant species. *Plant Ecolog.* 213, 1955–1961.

Xuan, T. D., Minh, T. N., Trung, K. H., and Khanh, T.D. (2016). Allelopathic potential of sweet potato varieties to control weeds: *Imperata cylindrica*, *Bidens pilosa*, and *Ageratum conyzoides*. *Allelopathy J*. 38, 41-54.

Tables and Figures

Table 1. Height reduction (%) of hemp sebania (*Sesbanea herbacea*), junglerice (*Echinochloa colona*), and Palmer amaranth (*Amaranthus palmeri*) seedlings when watered with root leachates of nine sweetpotato cultivars averaged over four weeks.

Cultivar	junglerice	hemp sesbania	Palmer amaranth
Heartogold	19	5	5
Centennial	18	9	9
Evangeline	18	9	3
Hatteras	18	3	2
Bayou Belle-2	15	5	4
Bayou Belle-6	17	7	8
Beauregard-14	13	10	4
Beauregard-63	11	10	5
Stokes Purple	17	7	8
LSD[1]	6	3.5	3

[1] LSD = Least Significant Difference at 5% level of probability.

Table 2. Height reduction (%) of hemp sebania (*Sesbanea herbacea*), junglerice (*Echinochloa colona*), and Palmer amaranth (*Amaranthus palmeri*) seedlings when in contact with root leachates of sweetpotato over four weeks averaged across cultivars.

Week	junglerice	hemp sesbania	Palmer amaranth
1	27	13	6
2	16	5	3
3	11	6	5
4	10	5	6
LSD[1]	4	2	2

[1] LSD = Least Significant Difference at 5% level of probability.

Table 3. Biomass reduction (%) of hemp sebania (*Sesbanea herbacea*), junglerice (*Echinochloa colona*), and Palmer amaranth (*Amaranthus palmeri*) seedlings when in contact with root leachates of nine sweetpotato cultivars at four weeks after emergence.

Cultivar	junglerice	hemp sesbania	Palmer amaranth
Heartogold	28	4	10
Centennial	22	19	6
Evangeline	25	3	9
Hatteras	23	2	1
Bayou Belle-2	10	2	4
Bayou Belle-6	19	4	0.5
Beauregard-14	21	3	4
Beauregard-63	25	2	6
Stokes Purple	29	14	5
LSD[1]	13.5	6.6	5

[1] LSD = Least Significant Difference at 5% level of probability.

Table 4. Rainfall (mm), minimum and maximum temperature (˚C) history for 2021 from May through November in Fayetteville and Kibler, AR, 2021.

Month	Total Rainfall (mm)		Minimum temperature (˚C)		Maximum Temperature (˚C)	
	Fayetteville	Kibler	Fayetteville	Kibler	Fayetteville	Kibler
May	170	153	12	14	23	24
June	102	98	18	20	29	31
July	133	169	19	21	31	32
August	45	12	20	22	32	33
September	47	62	16	17	30	32
October	182	187	11	12	23	25
November	47	49	3	4	15	17

Table 5. Relative frequency (RF), relative density (RD), relative abundance (RAb), and importance value index (IVI) at 5 and 7 weeks after transplanting (WAT) in weedy plots with sweetpotato in Fayetteville, AR, 2021.

Weed species	RF (%)	RD (%)	RAb (%)	IVI (%)	RF (%)	RD (%)	RAb (%)	IVI (%)
	5 WAT				7 WAT			
	- Broadleaf weed species -							
Mollugo verticillata	29	43	34	105	29	33	35	96
Chenopodium album	7	9	10	26	6	7	2	16
Eclipta prostrata	9	2	2	14	13	7	10	30
Sesbania herbacea	3	0.8	3	6	2	0.8	0	3
Acalypha ostryifolia	12	4	11	26	12	6	16	33
Ipomoea hederacea	10	2	4	16	0	0.3	0	0.3
Ipomoea purpurea	2	0.6	3	6	0	0.2	0	0.2
Amaranthus palmeri	28	39	33	99	37	46	37	120
	- Grass weed species -							
Urochloa platyphylla	37	38	19	93	61	67	16	144
Cynodon dactylon	1	1	6	8	2	1	9	12
Eleusine indica	7	7	8	22	20	11	8	39
Setaria faberi	1	0.8	7	9	0	0	0	0
Echinochloa colona	15	20	25	60	13	19	31	64
Digitaria sanguinalis	0	1	10	11	1	0.5	10	12
Sorghum halepense	21	23	6	50	2	1	19	22
Festuca arundinacea	3	2	13	18	0	0	6	6
Setaria pumila	14	7	6	27	0	0	0	0

Table 6. Relative frequency (RF), relative density (RD), relative abundance (RAb), and importance value index (IVI) at 5 and 7 weeks after transplanting (WAT) in weedy plots with sweetpotato in Kibler, AR, 2021.

Weed species	RF (%)	RD (%)	RAb (%)	IVI (%)	RF (%)	RD (%)	RAb (%)	IVI (%)
	5 WAT				7 WAT			
	- - - - - - - - - - - - - - - - - - - Broadleaf weed species - - - - - - - - - - - - - - - - -							
Amaranthus palmeri	80	95	89	264	86	96	90	272
Mollugo verticillata	12	4	6	22	3	0.5	4	8
Ipomoea purpurea	8	2	4	14	10	3	7	20
	- Grass weed species - - - - - - - - - - - - - - - - - -							
Cynodon dactylon	3	1	6	10	0	0	0	0
Urochloa platyphylla	1	0.2	0.8	2	6	2	5	13
Eleusine indica	12	5	7	24	7	2	3	12
Echinochloa colona	41	65	52	158	42	62	52	156
Digitaria sanguinalis	26	21	24	71	33	31	32	96
Leptochloa panicoides	17	7	10	35	11	4	5	19
Cyperus esculentus	0	0	0	0	2	0.4	2	5

Table 7. Effect of weed infestation on yield averaged across nine sweetpotato cultivars, by grade (kg ha^{-1}), in Fayetteville and Kibler, AR, 2021.

Weed species	Jumbo		No. 1		Canner		Cull		Total Yield[1]	
	Fayetteville	Kibler	Fayetteville	Kibler	Fayetteville	Kibler	Fayetteville	Kibler	Fayetteville	Kibler
	kg ha^{-1}									
Weed-free	35,090	34,396	29,500	34,908	3,822	7,114	990	4,450	68,412	76,418
Broadleaf	5,019	9,630	10,217	13,612	4,120	3,450	1,519	1,277	19,356	26,692
Grass	7,050	12,041	19,041	16,123	5,844	5,169	1,652	1,595	31,935	33,333
LSD[2]	3,122	7,435	2,553	3,573	566	NS[3]	NS	654	3,438	8,210

[1] Total marketable is the aggregate of jumbo, no. 1, and canner grades.

[2] LSD = Least Significant Difference.

[3] NS = No significant differences between treatment means according to a α=0.05 when using Student's *t* test.

Table 8. Yield of sweetpotato cultivars by grade (kg ha^{-1}) averaged across weedy and weed-free plots in Fayetteville and Kibler, AR, 2021.

Cultivars	Jumbo		No. 1		Canner		Cull		Total Yield[1]	
	Fayetteville	Kibler	Fayetteville	Kibler	Fayetteville	Kibler	Fayetteville	Kibler	Fayetteville	Kibler
	------------------------------kg ha^{-1}------------------------------									
Beauregard-14	14,109	27,011	24,515	29,702	6,541	7,102	1,059	3,458	45,165	63,815
Beauregard-63	13,268	18,067	22,304	23,315	3,287	5,205	1,211	1,627	38,859	46,587
Bayou Belle-6	14,823	32,597	28,563	32,246	5,272	14,076	984	2,572	48,658	78,919
Bayou Belle-2	14,100	23,594	21,156	23,695	2,792	5,790	956	2,452	38,048	53,079
Heartogold	4,903	12,902	21,617	13,166	7,406	2,894	2,429	4,956	33,926	28,962
Morado	40,083	17,901	7,891	10,708	449	2,575	334	2,019	48,423	31,184
Hatteras	14,702	11,148	19,255	24,038	6,521	2,795	2,548	697	40,478	37,981
Centennial	9,287	12,439	23,304	19,394	6,961	3,892	2,230	2,245	39,552	35,725
Evangeline	16,201	6,406	7,666	17,665	2,132	2,871	735	1,941	26,000	26,942
LSD[2]	5,411	7,864	3,768	5,437	1,211	3,540	517	NS	5,041	10,122

[1] Total marketable is the aggregate of jumbo, no. 1, and canner grades.

[2] LSD = Least Significant Difference.

[3] NS = No significant differences between treatment means according to a α=0.05 when using Student's *t* test.

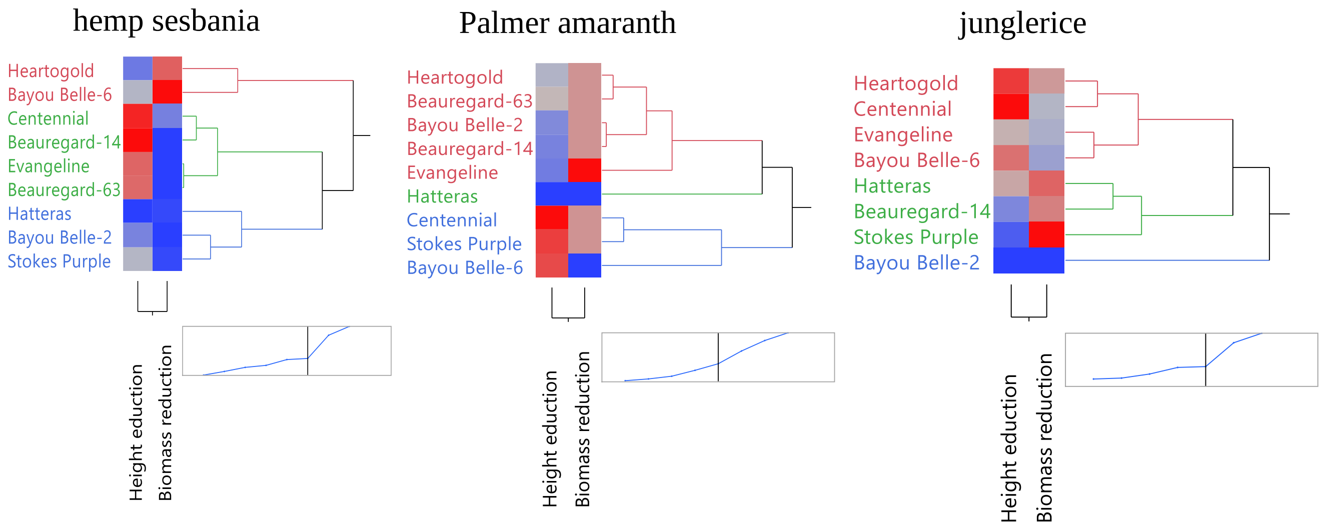

Figure 1. Clustering of sweetpotato cultivars based on height and biomass reduction of hemp sebania (*Sesbanea herbacea*), junglerice (*Echinochloa colona*), and Palmer amaranth (*Amaranthus palmeri*). Blue indicates a lower reduction percentage while red indicate a higher reduction percentage. Accessions grouped based on overall allelopathic potential.

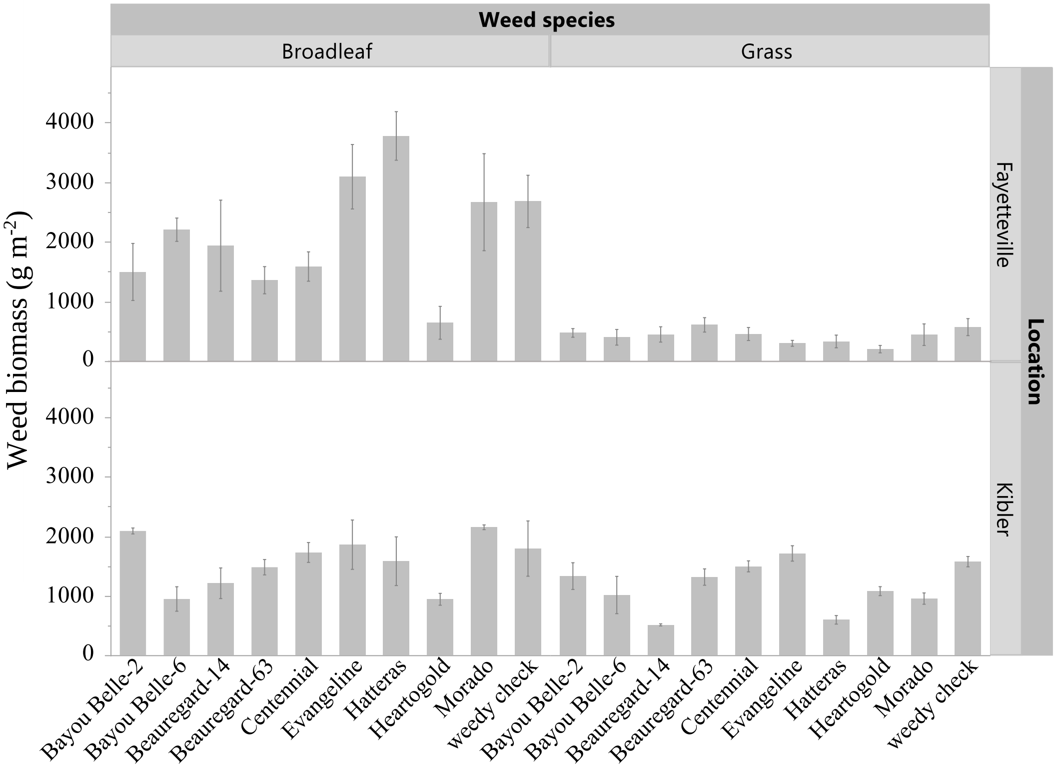

Figure 2. Effect of sweetpotato cultivars on broadleaf spp. and grass spp. biomass (g m^{-2}) in Kibler and Fayetteville, AR, 2021. LSD to compare cultivars within location Fayetteville: 496 g m^{-2}. LSD to compare cultivars within location Kibler: 453 g m^{-2}. Bars represent standard error.

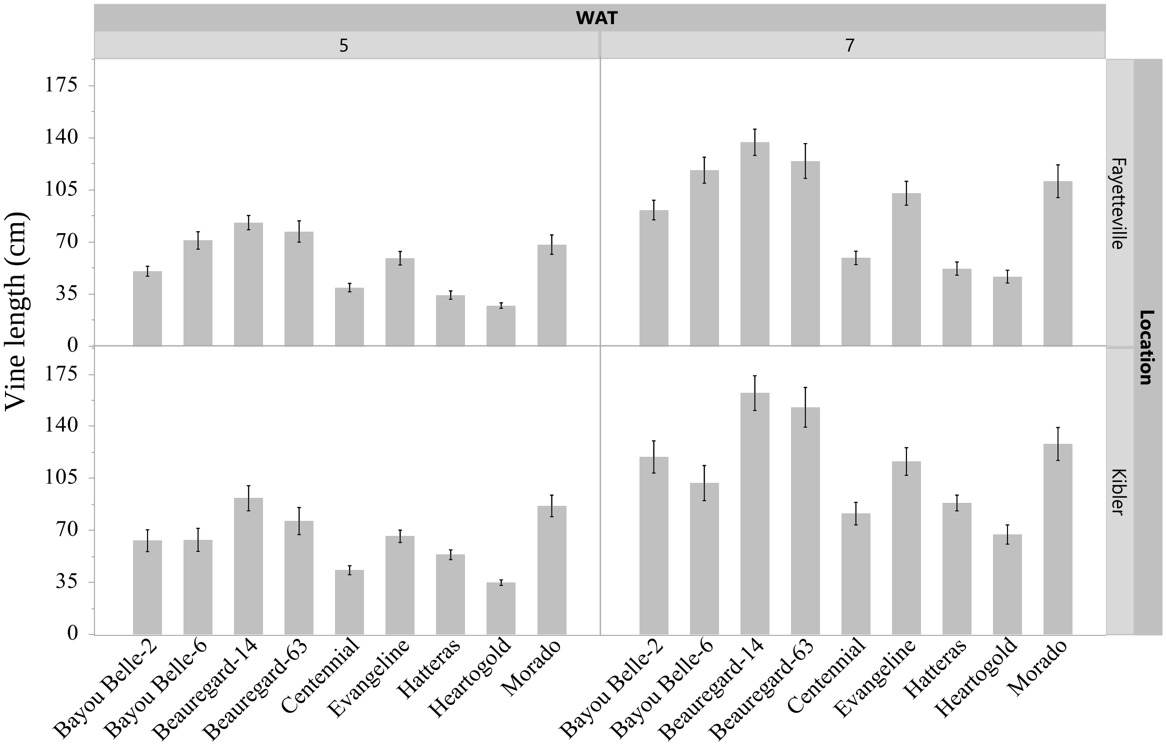

Figure 3. Sweetpotato length (cm) averaged across weed species at 5 and 7 weeks after transplanting (WAT) in Kibler and Fayetteville, AR, 2021. LSD to compare cultivars within location Fayetteville at 5 and 7 WAT: 7 cm; 10 cm. LSD to compare cultivars within location Kibler at 5 and 7 WAT: 9 cm; 12 cm. Bars represent standard error.

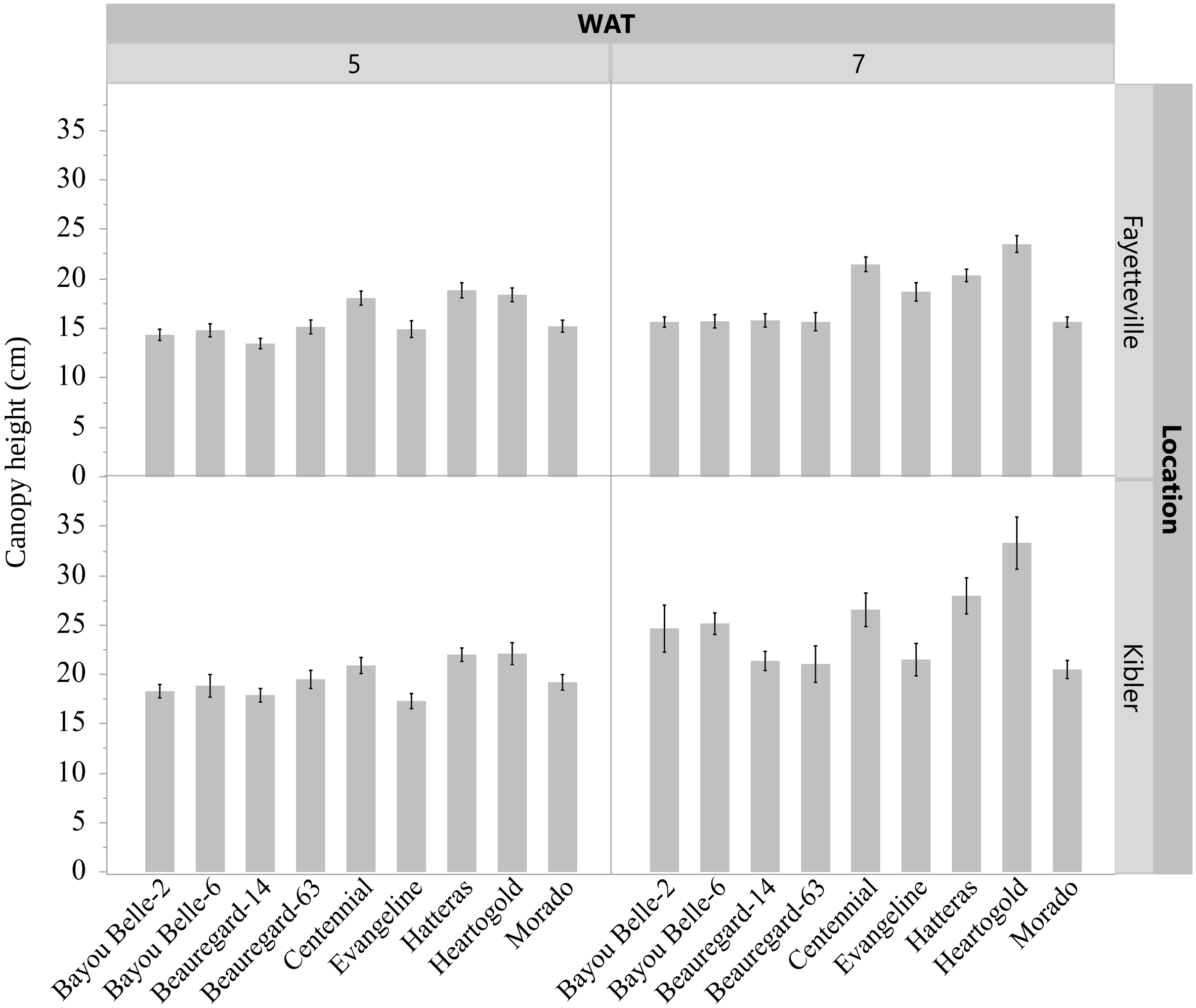

Figure 4. Sweetpotato canopy height (cm) averaged across weed species at 5 and 7 weeks after transplating (WAT) in Kibler and Fayetteville, AR, 2021. LSD to compare cultivars within location Fayetteville at 5 and 7 WAT: 1 cm; 1 cm. LSD to compare cultivars within location Kibler at 5 and 7 WAT: 1 cm; 2 cm. Bars represent standard error.

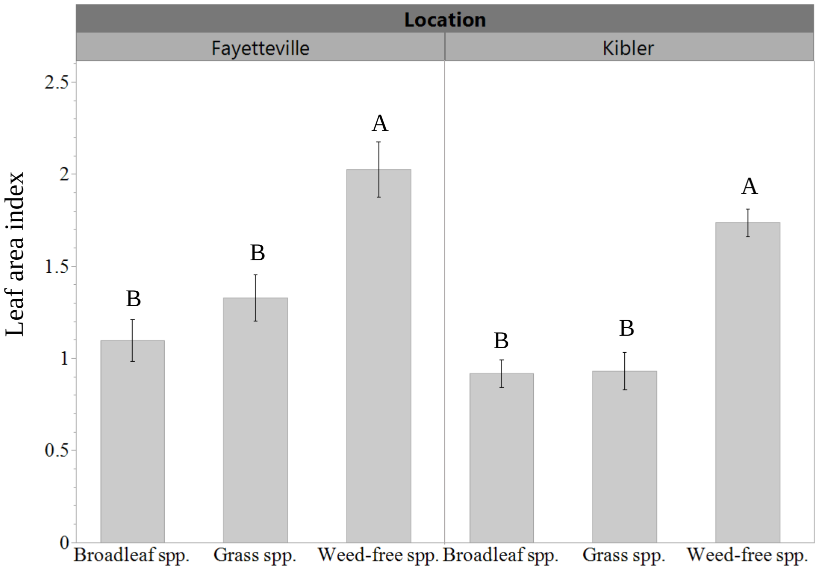

Figure 5. Leaf area index (LAI) averaged across cultivars when growing in weedy or weed-free conditions in Kibler and Fayetteville, AR, 2021. Means that do not share the same letter are significantly different from each other within a location (p≤0.05). Bars represent standard error.

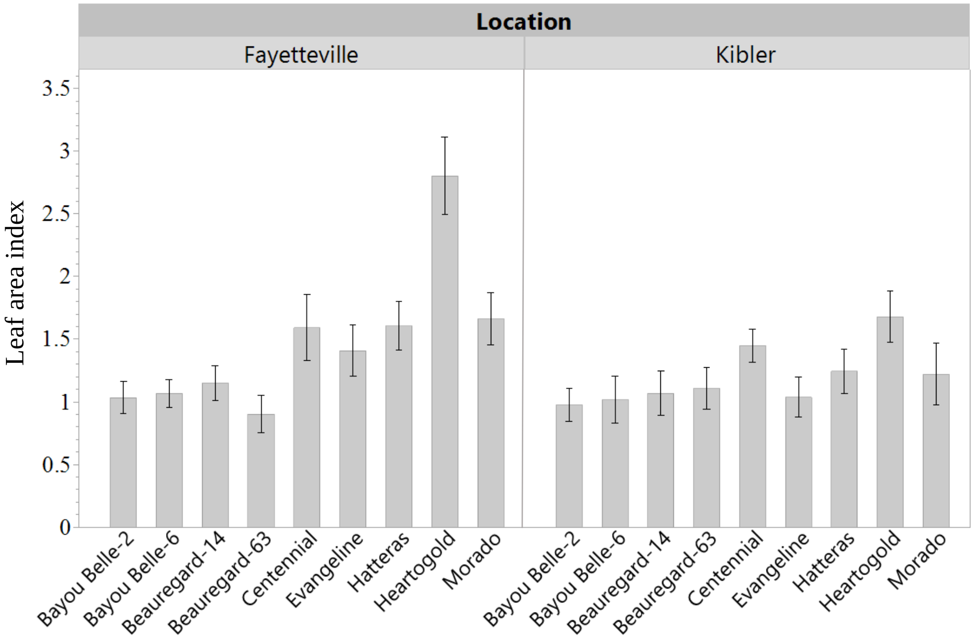

Figure 6. Leaf area index (LAI) of sweetpotato cultivars in Kibler and Fayetteville, AR, 2021. LSD to compare cultivars within location Fayetteville: 0.23; LSD to compare cultivars within location Kibler: 0.15. Bars represent standard error.

Performance of Sweetpotato Cultivars Under *Cyperus* spp. Interference

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Abstract

Perennial *Cyperus* species are very difficult to manage in sweetpotato (*Ipomoea batatas* L.) production. Weed-suppressive cultivars could be an effective supplemental tool for weed management. This study evaluated the weed suppressive ability of nine sweetpotato cultivars under yellow nutsedge (*Cyperus esculentus* L.) interference. Field experiments were conducted in 2021 in Kibler and Fayetteville, AR. The split-plot studies evaluated weed removal (weeded or not weeded) as whole plot and nine sweetpotato cultivars as split-plot. Canopy height and vine length were measured at 5 and 7 weeks after transplanting (WAT). Leaf area was measured at 12 WAT. The dry shoot biomass of yellow nutsedge was measured at 12 WAT. Total marketable yield (jumbo, no. 1, and canner grades) was harvested from six plants per plot. There was no cultivar by weeding interaction effect ($p>0.05$) for vine length, canopy height, and leaf area index (LAI). With yellow nutsedge, canopy height was taller, LAI was smaller, and vine length was shorter regardless of cultivar. 'Heartogold' and 'Centennial' had the tallest plant canopy in Kibler and Fayetteville. 'Heartogold', 'Centennial', and 'Hatteras' had the shortest vine length at both locations (<100 cm). 'Heartogold' had the greatest LAI in Fayetteville and Kibler. All cultivars reduced yellow nutsedge shoot biomass by 2-fold in Fayetteville, while 'Heartogold' caused the most weed biomass reduction (2.6-fold) in Kibler. Sweetpotato yield averaged 8,810 and 27,317 kg ha^{-1} in Fayetteville and 17,020 kg ha^{-1} and 39,522 kg ha^{-1} in Kibler with and without full-season interference of yellow nutsedge, respectively. 'Bayou-belle-2', 'Bayou Belle-6', 'Hatteras', and 'Centennial' where the highest yielding cultivars in weedy or weed-free conditions at both locations.

Introduction

Yellow nutsedge is a perennial weed in the sedge family (*Cyperaceae*), that produces extensive underground rhizomes and tubers [1,2]. Yellow nutsedge emerges in late April to early May and spreads rapidly within a field [3,4]. A single tuber can produce more than 360 tubers within four months, and a densely populated patch of approximately 1,100 shoots m^{-2} after six months [5]. Because of its high vegetative growth, the management strategies for yellow nutsedge should be focused on integrated practices that subject the weed to multiple stresses. Early detection and control are important, especially in mid- to late spring at seedling emergence or late summer during tuberization when the weed is most susceptible to management interventions [6,7].

A marketable yield loss of 698 kg ha^{-1} is expected for every week that yellow nutsedge is allowed to compete with sweetpotato (*Ipomoea batatas* L.) in the field [8]. To limit yield loss to a 10% level, yellow nutsedge densities should not be greater than 8 shoots m^{-2} [6]. *S*-metolachlor is the only herbicide with activity on yellow nutsedge registered in sweetpotato. As a preemergence herbicide, *S*-metolachlor is not effective if yellow nutsedge plants have emerged. However, sweetpotato stunting and decreased marketable yield may result from applications made immediately after transplanting. This phytotoxicity is reduced when the herbicide is applied 2 wk after transplanting (WAT) [9,10], but there is a risk that yellow nutsedge plants emerge before a delayed *S*-metolachlor application. Current recommendations for postemergence control rely on timely cultivation during the initial flush of yellow nutsedge emergence in late spring. However, it does little to control weeds in the planted row. Handweeding is another practice often used for weed control in sweetpotato fields [11]; to be effective, however, both the stem and root system of yellow nutsedge must be removed as the meristematic growing point of these plants is below the soil surface and each tuber produces new shoots

Choosing a competitive cultivar that can produce shade between rows after the last cultivation could help suppressing weed growth. Studies in corn (*Zea mays* L.) [12], cotton (*Gossypium hirsutum* L.) [13], cowpea (*Vigna unguiculata* L.) [14], potato (*Solanum tuberosum* L.) [15], wheat (*Triticum aestivum* L.) [16], rice (*Oryza sativa* L.) [17], and soybeans [*Glycine max* (L.) Merr.] [18] indicated differences in cultivar ability for weed suppression. Canopy formation is a vital tool to reduce weed emergence. Growers can better utilize canopy closure by selecting a fast-growing cultivar, with tall canopy, and increased leaf area index (LAI). Growth rate influences light interception and alter light quality, both of which have been shown to impact weed emergence. The phytochrome conversion of Pr (red) and Pfr (far red) is important for germination of problematic weed species. For instance, the incidence of Pr light promoted the germination of redroot pigweed (*Amaranthus retroflexus* L.), common waterhemp (*Amaranthus tuberculatus* Moq. Saur) and Palmer amaranth (*Amaranthus palmeri* S. Watson), whereas Pfr reduced the germination of these weeds [19].

Sweetpotato cultivars display a striking morphology variation in branching, leaf size, root shape and color, and overall yield potential [20]. Cultivars with upright growth have been indicated as better weed suppressors than those with spreading, viney characteristics. Studies comparing two cultivars with distinct canopy structures suggested that weed biomass was higher in plots with ‘Beauregard’, a viney cultivar, when compared to ‘Carolina Bunch’, which has shorter stems and taller canopy. ‘Beauregard’ is currently one of the most grown cultivars in the southeastern sweetpotato production belt. The prostrate vining characteristics of this cultivar makes it particularly susceptible to weed interference [22]. Other important commercial cultivars are ‘Covington’, ‘Orleans’, and ‘Bayou Belle’, but few studies have examined the influence of these cultivars on weed growth, and the possible traits contributing to a higher ability in suppressing weeds. Therefore, the objectives of this study were to (1) determine the weed suppressive or weed tolerance ability of sweetpotato cultivars with different canopy architectures to yellow nutsedge interference, and to (2) identify plant canopy characteristics that increase sweetpotato ability to suppress yellow nutsedge.

Materials and Methods

Experiments were conducted in Arkansas, USA in 2021, at the Vegetable Station (35°22’44.249’’ N, 94°13’59.506’’W), Kibler and at the Shult Agricultural Research and Extension Center (36°5’56.786’’ N, 94°10’43.9’’W), Fayetteville. The soil in the Fayetteville site was silt loam with pH 7.1 and nutrient contents of P, K, Ca, Mg, S, Na, Fe, Mn, Zn, Cu, and B at 49, 103, 1073, 40, 7.1, 7.4, 88, 213, 2.2,1.3, and 0.4 mg kg^{-1}, respectively. In Kibler the soil was silt loam with pH 7.1 and nutrient contents of P, K, Ca, Mg, S, Na, Fe, Mn, Zn, Cu, and B at 110,101,799, 149,6.1, 17.3, 229,72, 2.1, 1.0, and 0.4 mg kg^{-1}, respectively. Average rainfall from May to November was 727 mm in Fayetteville and 731 mm in Kibler (Figure 1).

Prior to sweetpotato transplanting, complete fertilizer (13-13-13) was applied at 227 kg ha^{-1} was applied, and the field was bedded. Sweetpotato cuttings (20- to 30-cm long) were hand-transplanted into bedded rows 46 cm apart in a horizontal position on June 03, 2021, and June 18, 2021, in Fayetteville and Kibler, respectively. The experiments were set up as randomized complete block, split-plot design with four replications. The whole plot consisted of weeding treatment (with or without yellow nutsedge) and the split-plot consisted of nine sweetpotato cultivars (‘Heartogold’, ‘Centennial’, ‘Evangeline’, ‘Hatteras’, ‘Bayou Belle-2’, ‘Bayou Belle-

6’, ‘Beauregard-14’, ‘Beauregard-63’, and ‘Morado’). A weed-only plot was established as a check in each whole plot. Plots consisted of two bedded rows, each 0.9 m wide and 15 m long, which were then subdivided into split-plot consisting of one row, 0.9 m wide and 3.0 m long. A native yellow nutsedge population was predominant at both locations and allowed to grow unchecked in weedy plots. Both locations received postemergence application of clethodim (Select Max®, Valent U.S.A. LLC Agricultural Products, Walnut Creek, CA) at 140 g ai ha^{-1} plus Crop Oil Concentrate (COC) at 0.25% v v^{-1}. Weed-free plots were hand-weeded every other week until 12 WAT. Urea fertilizer (32-0-0) was applied at 45.5 kg ha^{-1} along the side of sweetpotato plants 8 wk after transplanting (WAT).

Data were collected from the two inner sweetpotato plants of each plot. The canopy height and length of the longest vine were measured at 5 and 7 WAT. Sweetpotato leaves were collected from a 0.13 m^2 ground area 1 wk prior to harvest. Leaf area was measured using Li-cor Model 3100 leaf area meter (Li-cor Inc. Lincoln, Nebraska, USA) and then converted to leaf area index (LAI), as follows:

$$\mathrm{LAI} = \frac{\mathrm{Leaf\ area\ (m^2)}}{\mathrm{Ground\ cover\ (m^2)}}$$

Yellow nutsedge shoot biomass was collected 2 wk before harvest from a 0.25 m^2 in each split-plot. Samples were then placed in a forced-air drier for 120 h at 80°C. Dry biomass was recorded. Sweetpotato storage roots were harvested from all the six plants in the plot at 128 and 137 d after transplanting (DAT) in Fayetteville and Kibler, respectively. Roots were graded into jumbo (8.9 cm in diameter), no. 1 (≥4.4 cm but <8.9 cm), canner (≥2.5 cm but <4.4 cm), and cull (misshapen roots) [23], then weighed by grade. Total marketable yield was calculated as the sum of jumbo, no. 1, and canner grades.

Data were analyzed by JMP® Pro 16.1 (SAS Institute Inc., Cary, NC), with the fixed effect of weed species, sweetpotato cultivars, and their interaction. The replications within location and the error associated with the whole plot and residual (split-plot) were considered random effects. The experiments were analyzed by location. Significant differences between the means were determined at 5% level of probability ($p \leq 0.05$), and mean values were separated using Student's t-test. This experiment can be described with the following linear model:

$$Y_{ijk} = \mu + Bl_i + A_j + \eta_{ij} + B_k + AB_{jk} + \varepsilon_{ijk}$$

Where Y_{ijk} is the response variable, Bl_i is the random effect of blocks, A_j is the fixed effect of weeding (whole plot) on the response variable, η_{ij} is the whole plot error, B_k is the fixed effect of sweetpotato cultivars (split-plot) on the response variable, AB_{jk} is the fixed effect of the interaction between weeding and cultivars, and ε_{ijk} is the split-plot error. Bl_i, η_{ij}, and ε_{ijk} are assumed to be independent of one another.

Results

Yellow nutsedge biomass

The spatial distribution and density of yellow nutsedge varied across the fields. However, all plots contained a high population and weed coverage. Yellow nutsedge biomass differed across sweetpotato cultivars in Kibler (p=<0.0001) (Figure 2). 'Hatteras', 'Heartogold', and 'Centennial' suppressed weed growth the most, and had 75, 60, and 62% lower biomass than the weedy check (359 g m^{-2}). 'Bayou Belle-6', 'Bayou Belle-2', 'Beauregard-14', and 'Morado' had equal or higher weed biomass than the weedy check. In Fayetteville, weed biomass in the weedy check plot was 325 g m^{-2}. All cultivars reduced weed biomass similarly, which ranged from 131 to 200 g m^{-2} with the presence of sweetpotato.

Cultivar characteristics: vine length, canopy height, LAI

Cultivars did not differ ($p \geq 0.05$) in their canopy height at 5 WAT in Fayetteville and Kibler (Figure 3). At 7 WAT in Fayetteville, 'Heartogold' had the tallest canopy (26 cm), and was similar to 'Centennial', 'Beauregard-63', 'Hatteras', and 'Bayou Belle-6' (23-25 cm). Similarly, 'Heartogold' had the tallest canopy (32 cm) at 7 WAT in Kibler. Plant canopy was taller when sweetpotato was grown in weedy conditions (Figure 4). Averaged across cultivars, sweetpotato plants in weedy plots were about 20% taller than those growing weed-free at 5 and 7 WAT in Fayetteville. Likewise, 25% points increase in canopy height was observed in weedy plots in Kibler, relative to weed-free plots, regardless of the evaluation time.

'Bayou Belle-6' had the longest vine length (94 cm) and was similar to 'Morado', 'Bayou Belle 2', 'Beauregard-14', and 'Beauregard-63' (83-89 cm) at 5 WAT in Fayetteville (Figure 5). 'Beauregard-14', 'Beauregard-63', and 'Evangeline' had the longest vines in Kibler, which ranged from 79 to 101 cm. At 7 WAT in Fayetteville, 'Morado', 'Beauregard-63', and 'Beaureagard-14' had the longest vines (115 -142 cm). The longest vine length at 7 WAT in Kibler was recorded with 'Evangeline', 'Beauregard-63', 'Bayou Belle-2', 'Beauregard-14', and 'Bayou Belle-6' (130 to 155 cm). 'Heartogold', 'Centennial', and 'Hatteras' had the shortest vine length at both locations, which was overall less than 100 cm at 7 WAT. Overall, vine length was reduced by 20% points in weedy plots in both locations (Figure 6).

The sweetpotato cultivars differed in leaf area in both locations (p=<0.0001) (Figure 7). 'Heartogold' had the greatest LAI (1.7) in Fayetteville, which was similar to 'Hatteras', 'Morado', and 'Centennial' (1.3-1.4). 'Heartogold' (2.3) and 'Hatteras' (1.9) had the greatest

LAI in Kibler. LAI was reduced by 70 and 55% with yellow nutsedge interference in Fayetteville and Kibler, respectively (Figure 8).

The multivariate analysis revealed that the morphological parameters (vine length, canopy height, and LAI) of the cultivars were not correlated with weed biomass reduction (Table 1).

Sweetpotato yield

The interaction between weeding and cultivar treatments was significant on jumbo and no. 1 yield in Fayetteville (p=0.0031) and Kibler (p=0.0051). Jumbo yield ranged from 0 to 2,579 kg ha^{-1} in weedy plots and from 2,601 to 18,926 kg ha^{-1} when growing weed-free in Fayetteville (Table 2). The highest jumbo yield was obtained with ‘Hatteras’ (18,926 kg ha^{-1}) in weed-free plots. In Kibler, jumbo yield was up to 6,261 kg ha^{-1} in weedy plots, and from 5,830 to 39,611 kg ha^{-1} in weed-free plots. ‘Beauregard-63’ had the highest jumbo yield (39,611 kg ha^{-1}) when growing weed-free in Kibler. Little difference across cultivars was observed in jumbo yield with yellow nutsedge interference. Overall ‘Morado’ yielded numerically more than other cultivars in both locations. ‘Bayou Belle-2’, ‘Beauregard-63’, and ‘Bayou Belle-6’ had the greatest no. 1 yield in weed-free plots in Fayetteville and Kibler (Table 2). ‘Bayou Belle-2’, and ‘Hatteras’ had the greatest no. 1 yield in weedy plots across locations.

The weeding by cultivar interaction was not significant for canner yields in Kibler and Fayetteville (p>0.05) (Table 3). The main effect of cultivars was significant in both locations. Averaged across weeding treatments, ‘Centennial’ (5,218 kg ha^{-1}) had the greatest canner yields in Fayetteville. In Kibler, ‘Bayou Belle-2’ (7,428 kg ha^{-1}), ‘Centennial’ (6,889 kg ha^{-1}), ‘Bayou Belle-6’ (6,232 kg ha^{-1}), and ‘Beauregard-14’ (5,727 kg ha^{-1}) had higher canner yields. Weed interference reduced canner yields (20-30%) in both locations.

The weeding by cultivar interaction was significant in Fayetteville (*p*=0.0011) and Kibler (*p*<0.0001) for sweetpotato total yield (Table 2). 'Bayou Belle-2', 'Hatteras', 'Bayou Belle-6', and 'Beauregard-63' were the high-yielding cultivars without weed interference in Fayetteville and yielded 44,528; 40,858; 38,495; and 42,661 kg ha^{-1}, respectively. In Kibler, 'Beauregad-63' yielded the most in weed-free conditions with 76,836 kg ha^{-1}. 'Bayou Belle-2', 'Bayou Belle-6', 'Hatteras', and 'Centennial' were the high-yielding cultivars in weedy plots across locations. Overall, yield loss due to yellow nutsedge interference averaged 70 and 60% in Fayetteville and Kibler, respectively.

Multivariate analysis indicates that leaf area index and morphological traits were most strongly correlated with yield grades (Table 4). The increase of leaf area index is associated with an increase in jumbo, no. 1, canner, and total sweetpotato yield. Positive correlations were recorded for vine length, jumbo, and no.1 grades, but the coefficients were small and overall, not significant. Canopy height was negatively correlated with yield grades.

Discussion

Several architecture traits related to weed suppression have been identified in crops. Studies in USA and Australia indicated that certain wheat cover crops with taller canopy were found to be more competitive against Italian ryegrass (*Lolium multiflorum* Lam.) and rigid ryegrass (*Lolium rigidum* Gaud.) [25,26]. Sorghum cultivars, MR Goldruch and Bonus MR, which are taller and produce more shoot biomass suppressed plant growth and seed production of Japanese millet (*Echinochloa esculenta* A. Braun) [27]. Leaf size, canopy height and tillering were of importance for weed suppression of wheat, barley, and oats [28]. Cultivars that rapidly shade the soil surface are generally more effective in suppressing weeds than slower growing cultivars. Summer annual weeds are particularly susceptible to crop shading [29]. In sweetpotato, leaf area, canopy height, and vine growth are determinant canopy characteristics for weed suppression. For instance, yield of ‘W-241’, a cultivar with erect growth habit, was reduced less than 20%, while 50 to 70% reduction in yield was recorded with other 13 cultivars tested, which were determined by a spreading growing [24].

‘Hatteras’, ‘Centennial’, and ‘Heartogold’ were important cultivars for weed biomass suppression in this study. These cultivars were generally characterized by short vines, tall canopy and a greater LAI compared to other cultivars tested. Correlation analysis suggested that the relationship between leaf area and canopy height in our study had little practical significance for weed biomass suppression. A positive correlation coefficient for weed biomass and vining growth suggested that an increase in weed biomass is associated with longer vines, meaning that viney cultivars like ‘Bayou Belle-6’ and ‘Bayou Belle-2’ were the ones with less weed suppressive potential. Cultivars with this growing pattern have a rapid spreading of vines, but much of the soil is left uncovered, and weeds can emerge in the open areas between vines.

Belowground traits were not evaluated in our study but can be associated with the differential competitive ability of these cultivars. Various studies indicate that root traits, including root elongation and number of roots, can be determinants for competition ability [30, 31]. Carbohydrate reserves are stored in sweetpotato roots unlike most other crops [32,33]. In this case, the roots are the ‘sink’ for photosynthates. A strong ‘sink’ characteristic is more important in determining sweetpotato yield [34], which may result in a higher tolerance to weed interference than those with superior canopy characteristics. These belowground characteristics could be particularly useful in organic systems, where soil nutrient deficiencies are likely to occur. Essentially, cultivars that avoid resource pool overlap with weeds are those with higher tolerance to low nutrient levels [35].

The significant difference in yield observed between locations is attributed to variability in nutrient contents in the soil. Significantly lower amounts of phosphorus (P) and potassium (K) were recorded in Fayetteville. Rooted crops are mainly carbohydrate producers and require a special K level. The activity of starch synthetase is trigged by K levels. In optimum potassium levels, the activity starch synthetase increases but when potassium it is lacking, the enzyme activity can be extremely low [36,37]. K content is also associated with primary processes of photosynthesis, and regulates plant transpiration, water uptake, and plant turgor [38]. P deficiency in sweetpotato plants typically result in tubers with lower gravity compared to those with adequate P nutrition. P also increase the weight and carotene content of tuberous roots [39]. However, studies indicate that sweetpotato yield is not affected when P is eliminated during cultivation [39, 40]. Furthermore, the micronutrients copper (Cu), zinc (Zn), manganese (Mg), magnesium (Mn), and sodium (Na) were deficient in Fayetteville. Studies have revealed that sweetpotatoes can suffer from Mg and S deficiencies; hence, their required level in the soil should be maintained [41].

We identified Bayou-belle-2', 'Bayou Belle-6', 'Hatteras', and 'Centennial' as high yielding cultivars in this study when growing weedy or weed-free. However, full-season yellow nutsedge interference reduced marketable yields on average more than fifty percent in comparison to weed-free plots at both locations, with minor differences in cultivar tolerance to this weed. These results agree with other studies that suggest a 67 to 80% yield loss with yellow nutsedge densities of 90 shoots m^{-2} [6]. In bell pepper (*Capsicum annuum* L.), 54 to 74% fruit yield reduction was recorded with 30 tubers m^{-2} [42]. Yellow nutsedge densities of 12 shoots m^{-2}

caused 40% yield loss in watermelon (*Citrullus lanatus* L.) [43]. Root sizing was also affected by weed interference. Yield of jumbo and no.1 grades were significantly reduced compared to canner grade. In a two-year study, no. 1 yield grade decreased by 23 to 96% in the first year, and 7 to 74% in the second year for yellow nutsedge densities of 5 to 90 shoots m^{-2}, respectively [6]. This can be associated with lower light interception due to shading, given that yellow nutsedge shoots remained above sweetpotato canopy well before harvest. Additionally, it is likely that the smaller leaf area also contributed to the observed reduction in sweetpotato yield. Leaf shape, size, and direction are associated to cell number, chlorophyll content, and photosynthesis rates, which ultimately trigger the photoassimilates assignment in storage organs [44,45].

LAI was a determinant for sweetpotato yield. Jumbo and no.1 grades were positively correlated to LAI, consistent with other studies showing positive correlation of sweetpotato yield with LAI (r=0.54) [46]. Higher LAI logically can result in greater photosynthetic activity, which in turn can increase the storage of carbohydrate reserves in sweetpotato roots [47]. However, the increase in LAI is not always expected to have a positive impact on storage roots. In some cases, high biomass accumulation (or being more leafy) can lead to a reduction in root yield because more energy is diverted to produce leaves instead of being stored in the roots. This can further explain the inverse correlation between canopy height and root yields observed in this study. The allocation of resources to upper ground parts accelerates growth, but reduces energy stored in non-photosynthetic tissues (i.e. roots) [48]. There are sweetpotato genotypes with low sink capacity in the storage root system, while meristems may have a greater sink capacity [49] and, therefore, a significant reduction of storage roots can be observed. Other studies revealed that yield differ according to plant type. Cultivars with semi-erect growth habit (75-150 cm) showed higher yields than widely spreading cultivars (>250 cm). Likewise, short plant internode (3-5 cm) resulted in a higher productivity compared to yield of plant with intermediate internode length (6-9 cm) [50]. On the contrary, our results suggest that vine length can slightly promote sweetpotato yield.

The cultivars responded differently to yellow nutsedge competition across locations. In general, ‘Hatteras’, ‘Centennial’, and ‘Heartogold’ suppressed yellow nutsedge significantly. These cultivars are characterized by short vines, erect growth habit, and high LAI. There is no evidence of a common morphological trait tested in this study that explains the weed suppressive ability of the cultivars. Nevertheless, a positive correlation between vine length and yellow nutsedge biomass suggests that viney cultivars as ‘Bayou Belle-6’, ‘Morado’, ‘Beauregard-14’, ‘Bayou Belle-6’ and ‘Beauregard-63’ are poor weed suppressors. Vine length and LAI were reduced with yellow nutsedge interference; however, sweetpotato canopy was generally taller in the presence of this weed. In other words, the petioles elongated in the presence of yellow nutsedge, understandably to access more light. Elongation of petioles and stems is a phytochrome-mediated light response when long wavelength is predominant as the situation is under shade [51]. There is a positive influence of LAI on storage root yields. Cultivars possessing a greater LAI are likely to have higher jumbo, no.1, and canner yields, and this was reflected in marketable yield. Sweetpotato cultivars showed an inverse relationship between canopy height and root yields. ‘Bayou Belle-2’, ‘Bayou Belle-6’, ‘Hatteras’, and ‘Centennial’ were the best performing cultivars when growing weedy or weed-free. The substantial reduction in yield of most of the cultivars in this study reassure the low tolerance of sweetpotato to yellow nutsedge interference.

References

1. Uva, R.H.; Neal, J.C.; DiTomaso, J.M. *Weeds of the Northeast*. Cornell University Press: Ithaca, NY, USA, 1997.

2. Holm, L.G.; Plucknett, D.L.; Pancho, J.V.; Herberger, J.P. *The world's worst weeds*. Kriegar: Malabar, FL, USA, 1991.

3. DeFelice, M.S. Yellow nutsedge (*Cyperus esculentus* L.): snack food of the gods. *Weed Technol.* **2002**, *16*, 901–907.

4. Patton, A.; Weisenberger, D. Yellow nutsedge control. Purdue Extension, West Lafayette, IN. Available online: https://www.extension.purdue.edu/extmedia/AY/AY-19-W.pdf. (accessed on 12 February 2022)

5. Webster, T.M. Patch expansion of purple nutsedgee (*Cyperus rotundus*) and yellow nutsedge (*Cyperus esculentus*) with and without polyethylene mulch. *Weed Sci.* **2005**, *53*, 839-845.

6. Meyers, S.L; Shankle, M.W. Interference of Yellow Nutsedge (*Cyperus esculentus*) in ‘Beauregard’ Sweet Potato (*Ipomoea batatas*). *Weed Technol.* **2015**, *29*, 854-860.

7. Ransom, C.V; R Rice, C.A.; Shock, C.C. Yellow nutsedge (*Cyperus esculentus*) growth and reproduction in responde to nitrogen and irrigation. *Weed Sci.* **2009**, *57*, 21-25.

8. Beam, S.C. Influence of Herbicides on the Development of Internal Necrosis of Sweetpotato and Herbicide Tolerance of Sweetpotato. Master’s thesis, North Carolina State University, Raleigh, NC, 2016.

9. Meyers, S.L.;Jennings, K.M.; Schultheis, J.R.; Monks, D.W. Evaluation of Flumioxazin and *S*-metolachlor Rate and Timing for Palmer Amaranth (*Amaranthus palmeri*) Control in Sweetpotato. *Weed Technol.* **2010**, *24*, 495-503.

10. Meyers, S.L.; Jennings, K.M.; Monks, D.W.; Miller, D.K.; Shankle, M.W. Rate and Application Timing Effects on Tolerance of Covington Sweetpotato to *S*-metolachlor. *Weed Technol.* **2013**, *27*, 729-734.

11. Haley, J.; Curtis, J. (USDA CSREES) Sweetpotato grower survey report of results for 2005 crop. Risk Avoidance and Mitigation Program (RAMP): Development of grower decision management tools to reduce risk and enhance sustainability of Southern sweetpotato pest management systems. (Personal communication)

12. Woolley, J. N.; M. E. Smith. Maize zea-mays plant types suitable for present and possible bean *Phaseolus vulgaris* relay systems in Central America. *Field Crops Res.* **1986**, *15*, 3-16.

13. Chandler, J.M.; Meredith, W.R. Yields of three cotton (*Gossypium hirsutum*) cultivars as influenced by spurred anoda (*Anoda cristata*) competition. *Weed Sci.* **1983**, *31*, 303–307.

14. Remison, S. U.The performance of cowpea [*Vigna unguiculata* (L.) Walp.] as influenced by weed competition. *J. Agric. Sci.* **1978**, *90*, 523-530.

15. Sweet, R.D.; Yip, C.P.; Sieczka, J.B. Crop varieties: Can they suppress weeds? *New York's Food and Life Sci.* **1974**, *7*,3–5.

16. Ramsei, R. E.; Wicks, G. A. Use of winter wheat {*Triticum aestivum*) cultivars and herbicides in aiding weed control in an ecofallow corn {*Zea mays*) rotation. *Weed Sci.* **1988**, *36*, 394-398.

17. Haefele, S. M.; Johnson, D. E. ; Bodj, D. M. ; Wopereis, M.C.S.; Miezan, K. M. Field screening of diverse rice genotypes for weed competitive- ness in irrigated lowland ecosystems. *Field Crops Res.* **2004**, *88*, 39-56.

18. Jannink, J.L.; Orf, J.H.,; Jordan, N.R.; Shaw, R.G. Index selection for weed suppressive ability in soybean. *Crop Sci.* **2000**,*40*, 1087-1094.

19. Gallagher, R.S.; Cardina, J. Phytochrome-mediated *Amaranthus* germination I: effect of seedburial and germination temperature. *Weed Sci.* **1998**, *46*, 48–52

20. Amankwaah, V.A. Phenotypic and Molecular Characterization of Released and Elite Sweetpotato Varieties in Ghana Compared with Virus-tested Putative Ramets. Doctoral Dissertation, Kwame Nkrumah University of Science and Technology, Ghana, 2012.

21. Harrison Jr, H.F.; Jackson, D.M. Response of Two Sweet Potato Cultivars to Weed Interference. *Crop Prot.* **2011**, *30*, 1291-1296.

22. Andrew, W.M.; Monks, D.W.; Batts, R.B.; Thornton, A.C. Sweetpotato Tolerance to Thifensulfuron Applied Postemergence. *Weed Tech* **2007**, *21*, 928-931.

23. USDA. United States Department of Agriculture United States Standards for Grades of Sweetpotatoes. Available online: https://www.ams.usda.gov/grades-standards/sweetpotatoes-grades-and-standards (accessed on 17 March 2022).

24. LaBonte, D.R.; Harrison, H.F.; Motsenbocker, C.E. Crop interference and tolerance to weeds in sweet potato clones. *HortScience* **1999**, *34*, 229-232.

25. Appleby, A.P.; Olson, P.D.; Colbert, D.R Winter-wheat yield reduction from interference by Italian ryegrass. *Agron. J.* **1976**, *68*, 463–466.

26. Reeves, T.G.; Brooke, H.D. The effect of genotype and phenotype on the competition between wheat and annual ryegrass (*Lolium rigidum* Gaud.). In Proceedings of the Sixth Asian-Pacific Weed Science Society Conference, Jakarta, Indonesia, 1977; pp. 167–172.

27. Wu, H.; Walker, S.R.; Osten, V.A.; Robinson, G. Competition of sorghum cultivars and densities with Japonese millet (*Echinochloa esculenta*). *Weed Biol. Manag.* **2010**, *10*, 185-193.

28. Seavers, G.P.; Wright, K.J. Influence of crop growth habit and canopy development on weed suppression. In *Optimising Cereal Inputs: Its Scientific Basis Aspects of Applied Biology*; Gooding, M.J.; Shewry, P.R., Eds.; Asociation of Applied Biologists: Warwick, UK, 1997; pp. 361–366.

29. Wicks, G.A.; Ramsel, R.E.; Nordquist; P.T., Schmidt, J.W.; Challaiah, O. Impact of wheat cultivars on establishment and suppression of summer annual weeds. *Agron. J.* **1986**, *78*, 59–62.

30. Satorre, E.H.; Snaydon, R.W. A comparison of root and shoot competition between spring cereals and Avena fatua L. *Weed Res.* **1992**, *32*, 45–55.

31. Stone, M.J.; Cralle, H.T.; Chandler, J.M.; Bovey, R.W.; Carson, K.H. Above- and belowground interference of wheat (*Triticum aestivum*) by Italian ryegrass (*Lolium multiflorum*).

Weed Sci. **1998**, *46*, 438–441.

32. De Oliveira, A.; Rodrigues, J.D.; De Pinho, S.Z. Analise de crescimento na cultura da batata submetida a diferentes laminas de irrigaçao. *Pesqui. Agropecu. Bras.* **2000**, *35*, 901–907.

33. Santos-Castellanos, M.; Segura Abril, M.; Nústez Lopez, C.E. Analisis de crecimiento y relacion fuente-demanda de cuatro variedades de papa (*Solanum tuberosum* L.) en el municipio de Zipaquira (Cundinamarca, Colombia). *Rev. Facul. Nal. Agron.* **2010**, *63*, 5253–5266.

34. Kuo, G.; Chen, H.-M. Source-sink relationships of sweetpotato. In *Sweetpotato technology for the 21st century*; Hill, W.A.; Bonsi, C.K.; Loretan, P.A., Eds.; Tuskegee University: Tuskegee, Ala, 1992; pp. 282–295.

35. Smith, R.G.; Mortensen; D.A., Ryan, M.R. A new hypothesis for the functional role of diversity in mediating resource pools and weed-crop competition in agroecosystems. *Weed Res.* **2010**,*50*, 37– 48.

36. Murata, T.; Akazawa, T. Enzymatic mechanism of starch synthesis in sweetpotato roots. I. Requirements of Potassium ions for Starch synthetase. *Arch. Biochem. Biophys.* **1968**, *26*,873-879.

37. Murata, T.; Akazawa, T. Enzymatic mechanism of starch synthesis in sweetpotato roots. II. Enhancement of the Starch synthetase activity by malto-oligosaccharitles. *Arch. Biochem. Biophys.* **1969**, *130*, 604-609.

38. Jackson, W.A.; Volk, R.J. 1968 - Role of potassium in photosynthesis and respiration. In: *The role of potassium in agriculture*. Kilmer, V.J.; Younts, S.E.; Brady, N.C., Eds.; American Society of Agrononomy: Madison, WI, USA, 1968; pp. 109-146.

39. Degras, L. Sweetpotato: *The tropical Agriculturalist*. Macmillan Ltd: Lima, Peru, 2003.

40. Jayawardenes, T. Phosphorusfertilizer and organic matter effect on yield of sweetpotato. *J. Agri. Sci.* **1985**, *36*, 33-65.

41. Halliday, D.J.; Trenkel, M.E. *IFA World Fertilizer Use Manual*. International Fertilizer Industry Association: Paris, France, 1992; pp. 142.

42. Motis, T.N.; Locascio, S.J.; Gilreath, J.P.; Stall, W.M. Seasonlong interference of yellow nutsedge (*Cyperus esculentus*) with polyethylene-mulched bell pepper (*Capsicum annuum*). *Weed Technol.* **2003**, *17*, 543–549.

43. Burker, R.S.; Stall, W.M.; Olson, S.M.; Schilling, D.G. Season-long interference of yellow nutsedge (*Cyperus esculentus*) with direct-seeded and transplanted watermelon (*Citrullus lanatus*). *Weed Technol.* **2003**, *14*, 751–754.

44. Zhu, X.-G.; Long, S.P.; Ort, D.R. Improving photosynthetic efficiency for greater yield. *Annu. Rev. Plant Biol.* **2010**, *61*, 235–261.

45. Mathan, J.; Bhattacharya, J.; Ranjan, A. Enhancing crop yield by optimizing plant developmental features. *Development* **2016**, *143*, 3283–3294.

46. Adubasim, C.V.; Law-Ogbomo, K.E.; Obalum, S.E. Sweetpotato (*Ipomoea batatas*) Growth and Tuber Yield as Influenced by Plant Spacing on Snady Loam in Humid Tropical Environment. *J. Trop. Agric. Environ. Exten.* **2017**,*16*,46-50.

47. Wubanechi, S. Effect of Planting Density on Growth and Yield of Sweet Potato (*Ipomea batatas* (L.) Lam) Varieties in Habru District, Northern Ethiopia. Mater's Thesis, Harmaya University, Ethiopia, 2014.

48. White, A.C.; Rogers, A.; Rees, M.; Osborne, C.P. How can we make plants grow faster? A source–sink perspective on growth rate. *J. Exp. Bot.* **2016**, *67*, 31–45.

49. Keutgen, N.; Mukminah, F.; Roeb, G.W. Sink strength and photosynthetic capacity influence tuber development in sweet potato. *J. Hortic. Sci. Biotech.* **2002**, *77*, 106–115.

50. Pérez-Pazos, J.V.; Rosero, A.; Martínez, R.; Pérez, J.; Morelo, J.; Araujo, H.; Burbano-Erazo, E. Influence of morpho-physiological traits on root yield in sweet potato (*Ipomoea batatas* Lam.) genotypes and its adaptation in a sub-humid environment. *Sci. Hortic.* **2021**, 109703.

51. Casal, J.J. Shade avoidance. *Arabidopsis book* **2012**, *10*, e0157.

Tables and Figures

Table 1. Pearson's Correlation coefficients between weed biomass, leaf area index (LAI), canopy height, and vine length.

Variable	by Variable	Correlation	Prob>|ρ|
LAI	Weed biomass	-0.0157	0.8960
Canopy height	Weed biomass	-0.0465	0.7021
Vine length	Weed biomass	0.1708	0.1637

Table 2. Jumbo, no.1 and total sweetpotato yields (kg ha^{-1}) in weed-free vs. weedy treatments in Fayetteville and Kibler, 2021, AR.

Cultivars	Jumbo		No. 1		Total yield[1]	
	Fayetteville	Kibler	Fayetteville	Kibler	Fayetteville	Kibler
Weed-free						
Bayou Belle-2	10,840	5,261	30,244	27,788	44,528	40,477
Bayou Belle-6	12,869	15,954	22,226	37,260	38,495	59,446
Beauregard-14	5,328	16,886	19,142	26,544	27,304	49,157
Beauregard-63	14,576	39,611	24,524	33,045	42,661	76,836
Centennial	2,601	5,830	14,962	28,165	22,781	40,884
Evangeline	5,908	7,391	10,997	12,414	18,675	21,311
Hatteras	18,926	9,567	19,142	17,431	40,858	29,875
Heartogold	2,745	22,784	16,756	19,913	23,430	45,567
Morado	5,458	17,491	4,291	5,202	11,141	24,415
LSD[2]	2,466	4,968	2,612	5,096	3,295	7,255
Weedy						
Bayou Belle-2	377	3,444	8,001	21,528	11,822	32,400
Bayou Belle-6	0	1,830	7,122	10,046	10,522	18,108
Beauregard-14	0	484	2,942	15,464	5,776	21,675
Beauregard-63	0	0	7,606	7,032	11,167	11,212
Centennial	379	2,604	5,236	16,826	10,833	26,319
Evangeline	1,546	1,512	2,104	10,494	5,420	13,512
Hatteras	807	1,812	10,208	11,392	13,805	16,081
Heartogold	0	0	4,718	10,979	8,647	13,849
Morado	2,579	6,261	2,642	1,758	6,613	9,741
LSD	2,372	4,462	2,500	4,678	3,493	7,305

[1] Total marketable is the aggregate of jumbo, no. 1, and canner grades.

[2] LSD - Least Significant Difference between means at 5% level of probability

Table 3. Canner and cull yields (kg ha^{-1}) of sweetpotato cultivars in weed-free vs. weedy treatments in Fayetteville and Kibler, AR, 2021.

Cultivars	Canner		Cull	
	Fayetteville	Kibler	Fayetteville	Kibler
Weeding				
Weedy	2,812	3,548	1,510	643
Weed-free	3,485	5,237	1,286	1,568
LSD[1]	120	NS[1]	NS	NS
Cultivars				
Bayou Belle-2	3,444	7,428	1,086	1,553
Bayou Belle-6	3,400	6,232	1,449	1,116
Beauregard-14	2,834	5,727	1,265	1,299
Beauregard-63	3,561	4,180	1,354	1,794
Centennial	5,218	6,889	2,669	1,166
Evangeline	1,770	1,506	850	300
Hatteras	2,790	2,877	1,327	997
Heartogold	3,929	2,870	2,171	655
Morado	1,392	1,722	411	1,067
LSD	678	1,368	394	NS

[1] LSD- Least Significant Difference between means at 5% level of probability.

Table 4. Pearson's Correlation coefficients between sweetpotato yield grades and morphological traits.

Yield grade	Morphological trait	Correlation	Signif Prob
Jumbo	Canopy height	-0.2945	0.0004*
Jumbo	Vine length	0.0612	0.4823
Jumbo	Leaf area index	0.4947	<.0001*
No.1	Canopy height	-0.3239	<.0001*
No.1	Vine length	0.1229	0.1573
No.1	Leaf area index	0.4613	<.0001*
Canner	Canopy height	-0.093	0.2728
Canner	Vine length	0.0501	0.5656
Canner	Leaf area index	0.2636	0.0014*
Cull	Canopy height	-0.0778	0.3592
Cull	Vine length	-0.1164	0.1804
Cull	Leaf area index	0.07	0.4045
Total Yield	Canopy height	-0.3338	<.0001*
Total Yield	Vine length	0.1144	0.1987
Total Yield	Leaf area index	0.5647	<.0001*

Significant coefficients at 5% probability level are denotated by *.

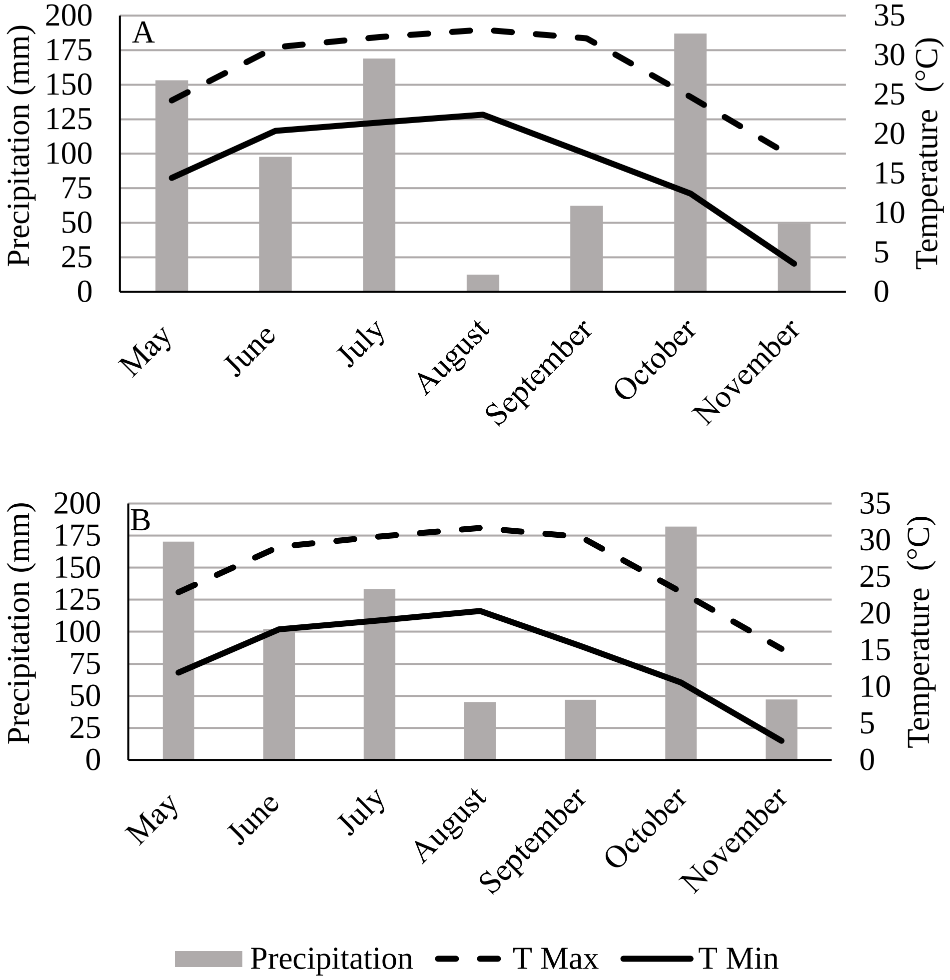

Figure 1. Monthly precipitation (mm), minimum temperature (°C), and maxium temperature (°C) in Kibler (A) and Augusta (B), AR, 2021.

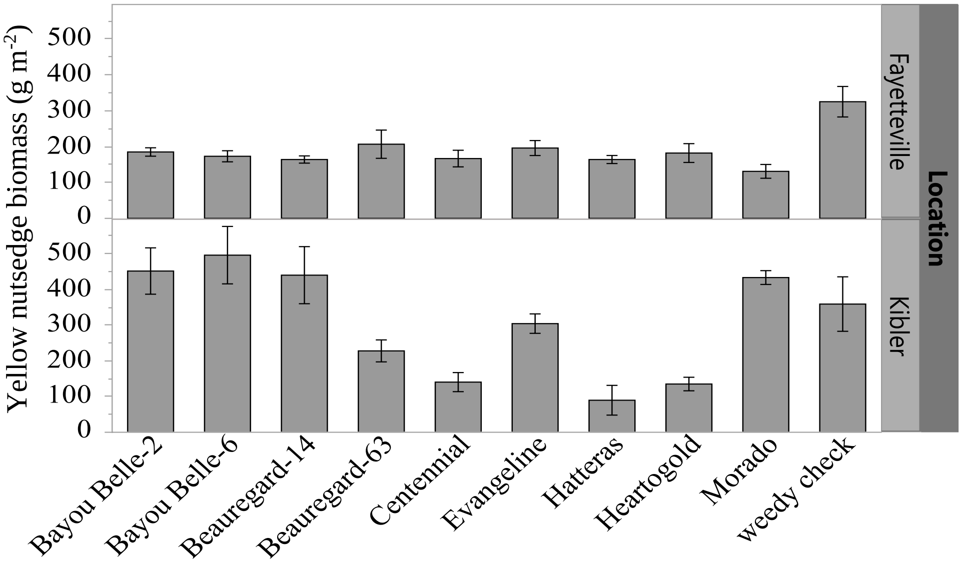

Figure 2. Yellow nutsedge (*Cyperus esculentus*) dry shoot biomass across sweetpotato cultivars in Fayetteville and Kibler, AR, 2021. LSD to compare cultivars within location Fayetteville: 30g m^{-2}; LSD to compare cultivars within location Kibler: 72g m^{-2}. Bars represent standard error.

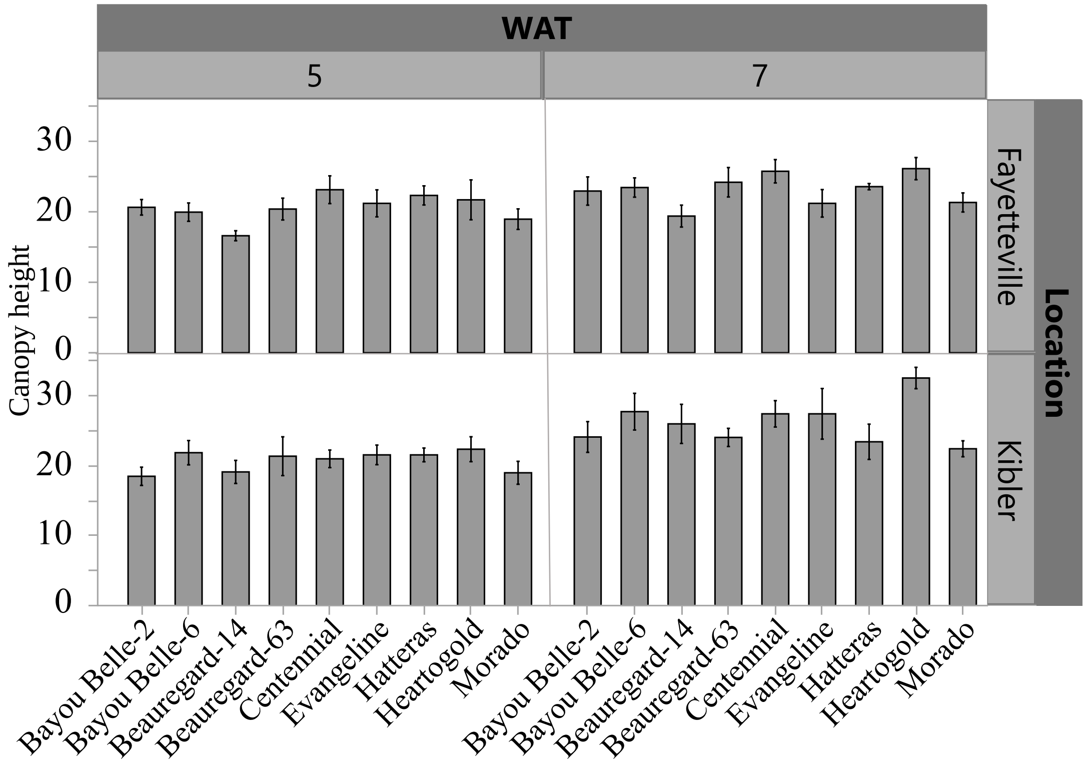

Figure 3. Sweetpotato canopy height at 5 and 7 weeks after transplanting (WAT) in Fayetteville and Kibler, AR, 2021. LSD to compare cultivars within location Fayetteville at 7 WAT: 1.8 cm; LSD to compare cultivars within location Kibler 7 WAT: 2.3 cm. Bars represent standard error.

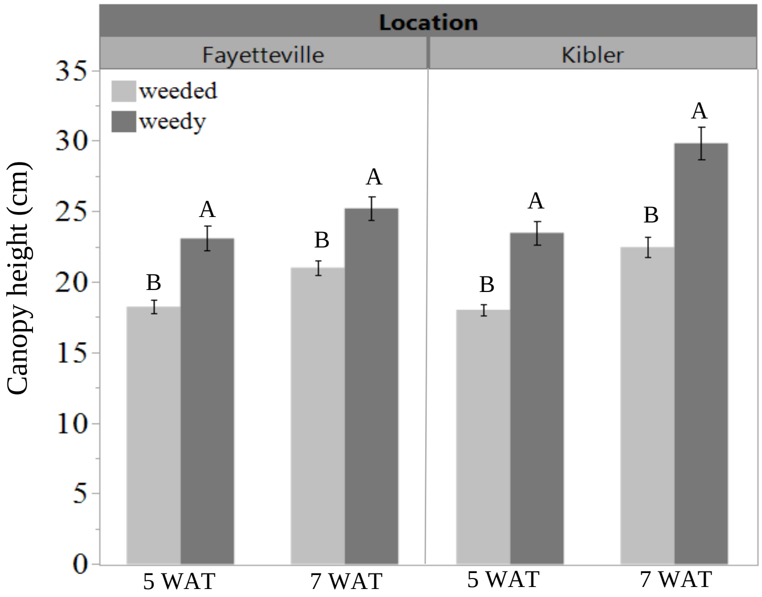

Figure 4. Sweetpotato canopy height averaged across cultivars in weed-free and weedy conditions in Fayetteville and Kibler, AR, 2021. Means that do not share the same letter are significantly different from each other within location and within weeks after transplanting (WAT) ($p \leq 0.05$). Bars represent standard error.

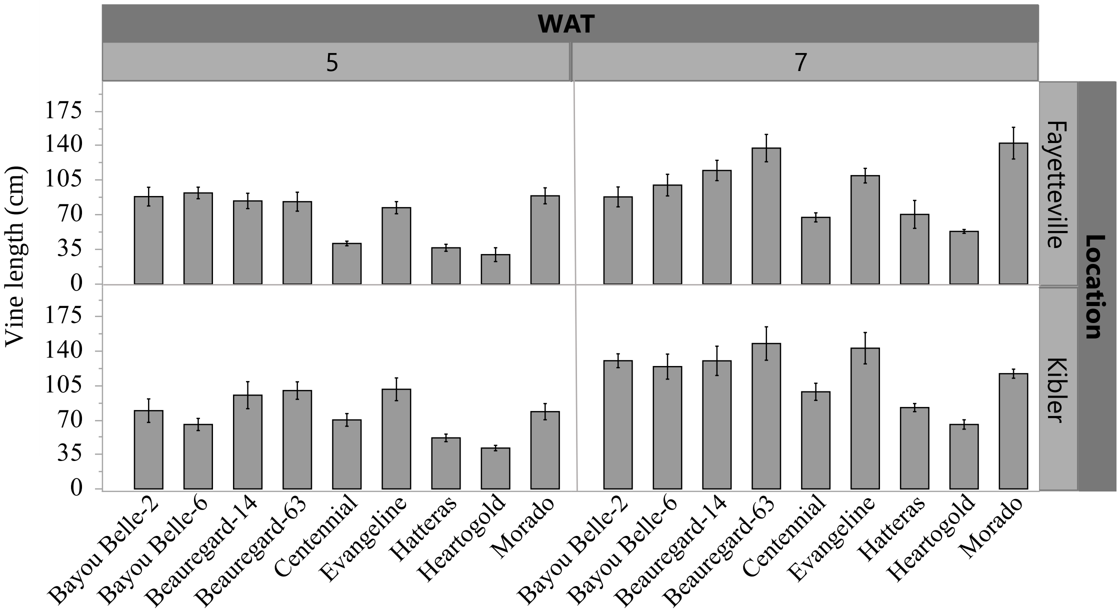

Figure 5. Sweetpotato vine length at 5 and 7 weeks after transplanting (WAT) in Fayetteville and Kibler, AR, 2021. LSD to compare cultivars within location Fayetteville at 5 and 7 WAT, respectively: 10 cm;15.5 cm; LSD to compare cultivars within location Kibler at 5 and 7 WAT, respectively: 13 cm; 14 cm. Bars represent standard error.

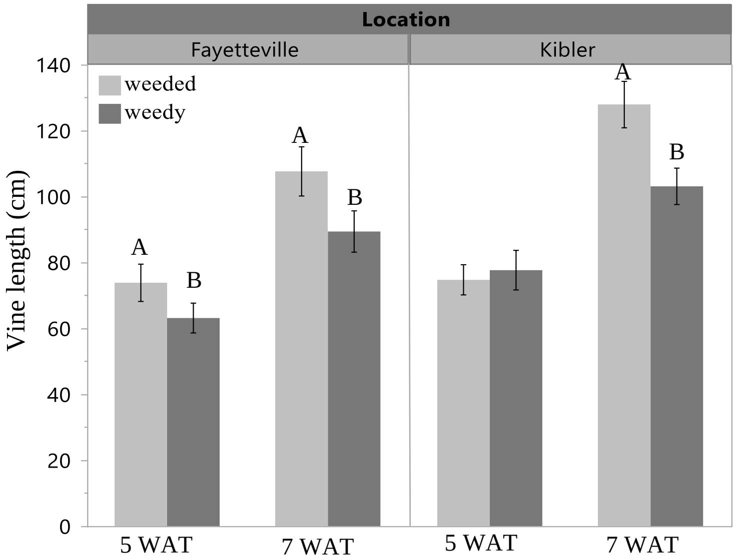

Figure 6. Sweetpotato vine length at 5 and 7 weeks after transplanting (WAT) in Fayetteville and Kibler, AR, 2021. Means that do not share the same letter are significantly different from each other within location and within weeks after treatment ($p \leq 0.05$). Bars represent standard error.

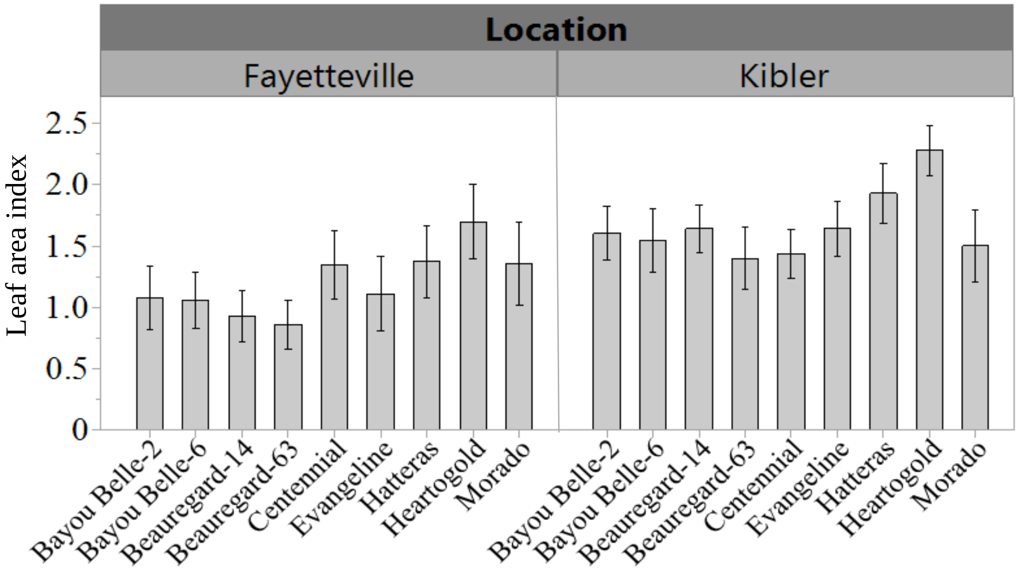

Figure 7. Leaf area index (LAI) of sweetpotato cultivars in Fayetteville and Kibler, AR, 2021. LSD to compare cultivars within location Fayetteville: 0.18; LSD to compare cultivars within location Kibler: 0.21. Bars represent standard error.

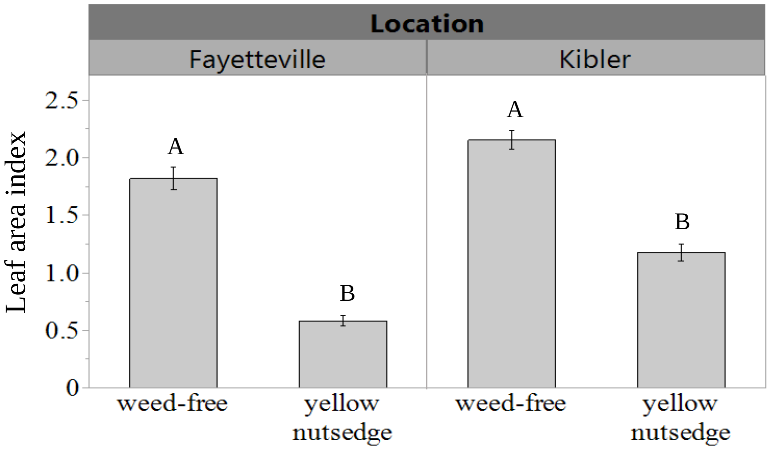

Figure 8. Leaf area index (LAI) averaged across cultivars in weed-free vs. weedy treatments in Fayetteville and Kibler, AR, 2021. Means that do not share the same letter are significantly different from each other within a location ($p \leq 0.05$). Bars represent standard error.

Integrating weed-suppressive cultivar and cover crops for weed management in organic sweetpotato production

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Abstract

Field studies were conducted in 2021 in Kibler and Augusta, AR, to determine the effect of winter cover crops and cultivar selection on weed suppression and sweetpotato (*Ipomoea batatas* L.) yield. The split-split plot studies evaluated three cover crops (cereal rye + crimson clover (*Trifolium incarnatum* L.), winter wheat (*Triticum aestivum* L.) + crimson clover (*Trifolium incarnatum* L.), and fallow) weeding (with or without), and four sweetpotato cultivars (‘Heartogold’, ‘Bayou-Belle-6’, ‘Beuaregard-14’, and ‘Orleans’). ‘Heartogold’ had the tallest canopy, while ‘Beauregard-14’ and ‘Bayou Belle-6’ had the longest vines at 5 and 8 weeks after sweetpotato transplanting. Sweetpotato canopy was about 20% higher in weedy plots compared to the handweeded treatment and vines were shorter under weed interference. Canopy development of sweetpotato cultivars was not related to weed biomass suppression. However, vine length was positively correlated to all yield grades. Plots with cover crops had lower weed biomass, especially with cereal rye + crimson clover. Cover crop biomass was positively correlated with jumbo, no.1, and total sweetpotato yields. Jumbo yields were affected the most by weed pressure. On average, sweetpotato total yield was reduced by 80 and 60% with weed interference in Augusta and Kibler, respectively. ‘Bayou Belle-6’ was the high-yielding cultivar with and without weed interference.

Introduction

Sweetpotato (*Impomoea batatas* L.) is ranked fifth highest in commodity sales among organic vegetable crops (USDA-NASS 2020). Roughly 3,695 ha of organic land and a total of 401 organic sweetpotato farms generated a production value of $77.1 million in 2019 (USDA-NASS 2020). When compared to conventional production, profitability could be up to 52% higher in organic production systems (Nwosisi et al. 2021). Despite the value-added, lower sweetpotato yields are to be expected compared to the conventional system (Nwosisi et al. 2021) because of weed management hurdles. Weed management is listed as the number one priority by organic farmers (Cerruti et al. 2015).

Cultivation has remained an important practice in managing weeds in both conventional and organic crop production (Haley and Curtis 2006). However, cultivation can only be done up to mid-season, before the vines start to overlap, due to the prostrate growth habit of sweetpotato. Handweeding is a common weed control practice in organic sweetpotato fields, but it requires a lot of man-hours of labor. The sweetpotato producing states including Arkansas, Mississippi, Louisiana, North Carolina, and California all reported labor shortage as one of the major challenges in sweetpotato production. Cover cropping is a simple practice that can reduce weed emergence. Cover crops can improve nutritional levels in soil and organic matter content, while also harboring beneficial organisms (De Laune et al. 2019). Legume cover crops, such as vetches (*Vicia* spp.) and clovers (*Trifolium* spp.), are particularly beneficial for soil properties, and can provide a good amount of fixed nitrogen (Finch 1993; McKinlay et al. 1996). As for example, crimson clover (*Trifolium incarnatum* L.) can fix 78 to 168 kg ha^{-1} of nitrogen, when grown as a winter annual and terminated at bloom stage (Clark 2007). Leguminous crops have a low C:N ratio and are quickly decomposed in the field, allowing for rapid availability of fixed N (Power

1994). Conversely, grass cover crops have high C:N ratio and whatever N is contained in its biomass is released slowly and may not be available to the current crop. The advantages of grass cover crops are its high biomass production and generally high allelopathic potential, which helps greatly in weed suppression (Davis 2010; Mirsky et al. 2013; La Hovary et al. 2016). In reduced-tillage systems, cover crops are seeded on raised beds in the fall and sweetpotato slips are transplanted directly through the cover crop residues (desiccated, mowed, or crimped) in the following spring (Smith 2011). Cover crop residues at sufficient amounts reduce evaporation loss of soil moisture; keep the soil temperature cool for a long period early in the growing season and keep the soil surface temperature cooler in the summer compared to bare plots; and reduce the amount of light penetrating the soil (Haynes and Tregurtha 1999; Rice et al. 2001; Teasdale and Mohler 1993). In this manner, cover crop residues not only reduce weed emergence, but also alter the germination behavior and seedling growth of weed species (Teasdale et al. 1998).

The adoption of a reduced-tillage system can be challenging for weed control because of the big role of cultivation in weed management. Weed-suppressive cultivars could be used as a tool for integrated weed management. Tolerance to weed interference is affected by the growth habit of the sweetpotato plants. Generally, crops with vigorous growth that reduce the quality and quantity of light beneath the crop canopy are the most competitive (Buhler 2002). Specific characteristics that tend to influence competitive ability of crops include leaf morphology, canopy closure, rapid biomass accumulation. In a study comparing the effect of two distinctly different shoot growth habits on weed suppression, plants with more vigorous initial growth, as well as shorter and more upright branches had higher tolerance to weed interference. ‘Beauregard-14’, which has long vines and more open shoot growth (i.e., smaller leaves spaced farther apart on the vine), was highly susceptible to weed interference because its growth habit allows high light penetration through the canopy. Conversely, ‘Carolina Bunch’, which has short vines, but with a dense and taller canopy (i.e., leaves with long petioles closely spaced along the vine) was more effective at suppressing weed growth (Harrison Jr. and Jackson 2011). ‘Orleans’ and ‘Beauregard-14’ are the most widely grown sweetpotato cultivars in Arkansas and account for about 60% and 40% of the state’s production, respectively (S Francis personal communication). These cultivars are distinguished by high yields, light-rose skin and orange flesh, and early production.

The objective of the study was to evaluate cover crop and sweetpotato cultivar benefits and their interaction related to weed suppression and marketable yield in an organic sweetpotato production system. We hypothesized that winter cover crops provide sufficient suppression of weed growth during the sweetpotato growing season, especially if paired with weed-suppressive cultivars. We also hypothesized that some sweetpotato cultivars, whether by allelopathy or competition, can withstand weed pressure while maintaining their yield potential.

Materials and methods

The field trials were performed at the Vegetable Research Station (35°22’44.249’’ N, 94°13’59.506’’W), Kibler, AR, and at an organic farm (35°17' 31.272" N, 91° 17' 44.3754" W, Augusta, AR. Total monthly rainfall ranged from 12 to 187 mm in Kibler and from 56 to 122 mm in Augusta (Figure 1). Over the entire cultivation period, the average temperature was 22°C and 21°C in Kibler and Augusta, respectively. Soil samples were collected by cover crop treatment and sent to the Agricultural Diagnostic Laboratory at the University of Arkansas, Fayetteville, AR for analysis (Table 1).

The experimental design was a randomized complete block, split-split plot, with 4 replications. The treatments consisted of: 1) weeding (whole plot, two levels); 2) cover crops (split plot, 3 levels); and 3) sweetpotato cultivars (split-split plot, 4 levels). Cover crop treatments included fallow, winter wheat (*Triticum aestivum* L.) + crimson clover (*Trifolium incarnatum* L.), and cereal rye (*Secale cereale* L.) + crimson clover. Each whole plot was divided into weeded or weedy split plots. Three sweetpotato cultivars ('Heartogold', 'Bayou Belle-6', and 'Beauregard-14') and a commercial standard cultivar 'Orleans' were included. Sweetpotato slips were produced in the greenhouse. The whole plot size was three rows, each 0.9 m wide and 12 m long, which were then subdivided into split-plot consisting of one row 0.9 m wide and 12 m long. The split-split plot was 0.9 m wide and 3.0 m long.

Cover crops were planted in the fall of 2020. Prior to planting, the field was prepared with a disk followed by a hipper, which formed 91 cm-wide beds for planting. Winter wheat and cereal rye were planted at a seeding rate of 90 kg ha^{-1} and crimson clover was planted at 11 kg ha^{-1}. Cover crop species and seeding rates were the same across locations but varied by planting method. Cover crops were drill-planted at the organic farm, and broadcast-seeded in Kibler. Cover crops were terminated in the spring of 2021 by flail mowing and residues were left on the soil surface. Sweetpotato transplants were obtained from greenhouse grown plants and cuttings (20- to 30-cm long) were transplanted manually on May 31st and June 4th of 2021 in Augusta and Kibler, respectively. A total of six slips per plot were planted in a horizontal position with two nodes buried, 46 cm apart in the row. Weeded plots were hand-weeded every other week until 12 weeks after transplanting (WAT), and native weeds were allowed to grow unchecked in the weedy plots.

Cover crop biomass was quantified by collecting above-ground portions of all plant material in a representative 0.25 m^2 area of each split-plot unit one week prior to cover crop termination. Samples were oven-dried at 70 °C for 72 h and weighed. Data on sweetpotato plants were collected from the 2 inner plants of each plot. The canopy height and length of the longest vine were measured at 5 and 8 WAT from two middle plants. Weeds were counted by species at 5 and 8 WAT from 0.25 m^2 quadrat in each split plot. Shoot biomass of weeds was collected from 0.25 m^2 from randomly placed quadrats two weeks before harvesting. All weeds in the quadrats were collected. Samples were then placed in a forced-air drier for 120 h at 80 °C and weighed. All sweetpotato plants in the plot were harvested at 153 and 141 d after transplanting (DAT) in Fayetteville and Kibler, respectively. The harvested roots were graded into jumbo (8.9 cm in diameter), no. 1 (≥4.4 cm but <8.9 cm), canner (≥2.5 cm but <4.4 cm), and cull (misshapen roots) (USDA, 2005), then weighted by grade. Total yield includes jumbo, no. 1, and canner grades.

The phytosociological parameters relative frequency (RF), relative density (RD), relative abundance (RAb), and importance value index (IVI) of broadleaf spp. and grass spp. treatments were assessed with the following equations (Werle et al. 2021):

$$\text{Frequency (F)} = \frac{\text{number of samplings in which the species were found}}{\text{total number of samplings}}$$

$$\text{Relative frequency (RF)} = \frac{\text{frequency x 100}}{\text{total species frequency}}$$

$$\text{Density (D)} = \frac{\text{number of plantsfound for the species}}{0.25\ \text{m}^2}$$

$$\text{Relative density (RD)} = \frac{\text{density x 100}}{\text{total species density}}$$

$$\text{Abundance (Ab)} = \frac{\text{number of plants found for the species}}{\text{total number of samplings in which the species was found}}$$

$$\text{Relative abundance (RAb)} = \frac{\text{abundance x 100}}{\text{total species abundance}}$$

$$\text{Importance value index (IVI)} = \frac{\text{RF x RD x RAb}}{\text{total species abundance}}$$

where RD, RF, and RAb are the number of species, their distribution, and abundance with other species in the sampled area, respectively. IVI indicates the most important species in the study area. Total frequency, density, and abundance were obtained from the sum of the relative number of each of the parameters.

The whole plot effect of cover crops, the split-plot effect of weeding, the split-split plot effect of sweetpotato cultivars, and their interaction were considered as fixed effects, and data were analyzed by location. The replications within locations and the error associated with the whole plot and residual were considered as random effects. This experiment can be described with the following linear model:

$$Y_{ijkl} = \mu + Bl_i + A_j + d_{ij} + B_k + AB_{jk} + f_{ijk} + C_l + AC_{jl} + BC_{kl} + ABC_{jkl} + \varepsilon_{ijkl}$$

where Y_{ijkl} is the response variable, Bl_i is the random effect of blocks, A_j is the fixed effect of weeding (whole plot factor) on the response variable, d_{ij} is the whole plot error, B_k is the fixed effect of cover crops (split-plot factor) on the response variable, f_{ijk} is the split-plot error, and C_l (split-split plot factor) is the fixed effect of cultivars on the response variable. The interactions between the main effect factors are represented by AB_{jk}, AC_{jl}, BC_{kl}, and ABC_{jkl}, while ε_{ijkl} is the split-split plot error.

Data were analyzed in JMP$^{®}$ Pro 16.1 (SAS Institute Inc., Cary, NC). We had three treatment factors, weeding (2 levels), cover crop (3 levels), and cultivar (4 levels). The analysis was performed using Standard Least Squares in the Fit Model platform to determine significant influences of cover crop, weeding, and cultivar, and their interactions on weed biomass, vine length, canopy height, sweetpotato yields. If a treatment effect was significant, Student's *t*-test was used for comparisons among treatments. Significant differences between the means were determined at a 5% level of probability ($p \leq 0.05$). Pearson's correlation analysis was performed to determine the relationship between weed biomass, cover crop biomass, vine length, canopy height, and sweetpotato yield grades.

Results and Discussion

Weed composition in the field

The weed community was composed of broadleaf, sedges, and grass species in both locations (Table 2). The weed species in Kibler and Augusta are the among the most problematic for sweetpotato growers (Monks et al. 2019). The three most important weed species in Augusta, were yellow nutsedge (*Cyperus esculentus*), eclipta (*Eclipta erecta*), and common knotweed (*Polygonum arenastrum*). In terms of population density, *C. esculentus* was the most numerous species at 5 WAT (RD=55%) and 8 WAT (RD=56%). *C. esculentus, E. erecta,* cutleaf evening-primrose (*Oenothera laciniata*), and *P. arenastrum* had the highest frequency of occurrence (RF=10-27%) at 5 WAT. *C. esculentus* and *P. arenastrum* contributed the most to weed abundance at 5 WAT with 39 and 20%, respectively. At 8 WAT, *C. esculentus* (RAb=48%) and *E. erecta* (RAb=19%) were the most abundant among weed species.

Crimson clover, winter wheat, and carpetweed (*Mollugo verticillata*) were present in all treatments at 5 WAT in Kibler, and crimson clover, goosegrass (*Eleusine indica*), and bearded sprangletop (*Leptochloa fusca*) at 8 WAT. Crimson clover had the highest frequency (RF=28%) and density (RD=141%), and wheat had the highest abundance (RAb=127%) at 5 WAT. Clover had the highest frequency (RF=16%) and density (RD=56%), and abundance (RAb=57%) at 8 WAT, followed by *E. indica* and *L. fusca.*

Canopy development

The interaction effect between cover crop, weeding, and cultivar treatments on vine length and canopy height was not significant at both location sites. The main effect of weeding was significant on canopy height at 5 WAT (p=0.0230) and 8 WAT (p=0.0003) in Augusta (Figure 2). Averaged across cultivars and cover crops, the canopy was taller under weedy conditions, with about 20% increase compared to the weeded treatment. Plants tend to grow taller when surrounded by other plants as a shade-avoidance mechanism. Shade-avoidance is a response of plants due to light signals provided by neighbor species that tend to reduce the quality of light (red or far-red wavelengths) available for photosynthetic processes (Casal 2012). Therefore, the increase in canopy height allows sweetpotato to reduce competition for light by getting its leaves above the canopy of adjacent weeds. This resource allocation is reflected in an increased shoot: root ratio, meaning that negative effect can be expected in root yields. At 8 WAT, canopy height differed across cultivars in Augusta (p=0.0230) and Kibler ($p \leq 0.0001$). ‘Heartogold’ had the tallest canopy (22.5 cm) in Augusta, which was similar to ‘Orleans’ (21 cm) (Figure 3). Similarly, ‘Heartogold’ had the tallest canopy (24 cm) in Kibler and was on average 6 cm taller than ‘Bayou Belle-6’ and ‘Orleans’ and 10 cm taller than ‘Beauregard-14’.

Vine length differed across cultivars at 5 and 8 WAT ($p \leq 0.0005$) in Augusta (Figure 4). ‘Beauregard-14’ and ‘Bayou Belle-6’ had the longest vines, with 33 cm and 28 cm at 5 WAT, and with 105 cm and 97 cm at 8 WAT, respectively. The effect of weed interference on sweetpotato growth was reflected on the length of vines ($p = 0.0002$) at 8 WAT. Overall, vine length was reduced from 107 cm in weed-free plots to 50 cm in non-weeded plots (Figure 5). This is consistent with other studies that indicate a 53% reduction in sweetpotato vine mass in weedy treatments (La Bonte et al. 1999). In Kibler, vine length differed across cover crops, weeding, and cultivar treatments at 5 and 8 WAT ($p \leq 0.05$). Similar to the cultivar differences in Augusta, ‘Beauregard-14’ (90 cm) and ‘Bayou Belle-6’ (78 cm) had the longest vines at 5 WAT. ‘Beaureagard-14’ had the longest vine (173 cm) at 8 WAT, which was approximately 25 cm longer than those of ‘Orleans’ and ‘Bayou Belle-6’, and 100 cm longer than that of ‘Heartogold’. At 5 WAT, longer vines (80 cm) were recorded in plots with cereal rye + crimson clover compared to winter wheat + crimson clover (64 cm) and fallow (62 cm). At 8 WAT, vine length was similar with cereal rye + crimson clover (149 cm) and winter wheat + crimson clover (142 cm) treatments, and roughly 30 cm longer than the fallow treatments. Vine length was about 20 cm shorter with weed interference at 5 and 8 WAT in this location.

Cultivar and cover crop ability to suppress weed growth

A cover crop by cultivar interaction ($p=0.0322$) was observed for weed biomass in Augusta. Weed biomass ranged from 195 to 380 g m^{-2} (Table 3). Significantly higher weed biomass was recorded in plots with winter wheat + crimson clover and planted with ‘Orleans’ (380 g m^{-2}) and in plots without cover crop and planted with ‘Beauregard-14’ (372 g m^{-2}). ‘Orleans’ is one of the commercial standard cultivars. Although weed biomass did not differ statistically between cover crops and cultivars in Kibler ($p \geq 0.05$), lower weed biomass was recorded in plots with cover crops, especially with cereal rye + crimson clover.

Collectively, studies demonstrate that cover crops can inhibit weed growth, but the performance of cover crops vary with climate, soil type, management systems, and many other factors. In this study, a reduced-tillage system was used where the cover crop residues remained on the soil surface after termination. In studies comparing cereal rye residues in reduced-tillage and conventional systems, the conventional tillage system had a 20% higher total yield than the reduced-tillage system (Smith 2021). Other studies also suggested a superior weed suppression when rye and rapeseed (*Brassica napus*) residues were tilled into the soil, resulting in up to a 27% reduction in weed density (Kaluwasha 2019).

From early investigations we learned that when cover crop residues remain on the soil surface, weed seed germination can be inhibited because of a change in the soil microenvironment as well as physical impediment of seedling emergence (Teasdale and Mohler 1993). The cover crop residues reduce solar radiation reaching the soil surface and alters thermal conditions, or release phytotoxic compounds that reduce weed emergence (Brennan and Smith 2005). Rye is a typical fall-planted cover crop that releases secondary metabolites (i.e., alkaloids, organic acids, sulfides) which accumulate on the soil surface and inhibit the germination of weed seeds. Benzoxazinoid compounds present in rye shoots are known to be allelopathic to giant foxtail (*Setaria faberi*), common lambsquarters (*Chenopodium album*), pigweeds (*Amaranthus* spp.), horseweed (*Conyza canadensis*) and barnyardgrass (*Echinochloa crus-galli*) (Burgos and Talbert 1996; Przepiorkowski and Gorski, 1994).

The differences observed in total nitrogen (N), total carbon (C), and organic matter via loss on ignition (LOI) between cover crop and fallow treatments were not significant in this experiment (Table 1). This result can be attributed to the time of soil sampling since soil analysis was performed only at 15 WAT following cover crop termination. In general, nitrogen mineralization from cover crop residues is intense in the first 30 days following termination. However, several factors (i.e. rainfall, temperature, soil type, soil management) can influence the rate of nutrient release and biomass decomposition (Clark 2007; Power 1994; Roberts et al. 2020). The breakdown of cover crops biomass is directly associated with C:N ratio of the residues. A high C:N ratio (C:N≥25:1) results in low amounts of N (kg N ha^{-1}) that would be slowly available, meanwhile a low C:N ratio (C:N <20:1) increase the speed of N release from the biomass following termination. Grasses, such as cereal rye, typically have high C:N ratios, whereas legumes as crimson clover have low C:N ratios (Ashford et al. 2003; Kuo and Jellum 2002). For instance, vetch residues in no-till or till systems were completely decomposed after a 3.5-month period. Conversely, rye residues showed a slower decomposition rate with approximately 20% in no-till decomposed, and 52% in full-till decomposed after 3.5 month of the termination (Collier 2017). Adding a legume component to a grass cover crop is expected to reduce the C:N ratio and improve the nutrient mineralization rate after cover crop termination. In our study, an initial rapid decomposition could have been favored by the low C:N ratio of the cover crops provided by the mix of crimson clover and cereal winter cover crops. Furthermore, rainfall volume and air temperature likely promoted N loss of cover crop residues in this study, especially in the first three months after cover crop termination. The combination of climatic factors and chemical composition of cover crop shoots are important in regulating biomass decomposition and nutrient release (Varela et al. 2017).

Sweetpotato Yield

A significant weeding by cultivar interaction was observed on jumbo yields (*p* =0.0024) in Augusta. In Kibler, the main effect of cultivar (*p*=0.0033) and weeding treatment (*p*=0.0033) on jumbo yields was significant. Jumbo yield was affected the most with weed interference, and yield ranged from 5,192 kg ha^{-1} in weeded plots to 204 kg ha^{-1} with weed interference in Augusta, and from 8,468 to 1,165 kg ha^{-1} with weed interference in Kibler (Table 4). Averaged across weeding treatments, the greatest jumbo yield (7,979 kg ha^{-1}) was obtained with 'Bayou Belle-6' in Kibler, which was similar to 'Heartogold' (5,797 kg ha^{-1}), and 'Beauregard-14' (5,546 kg ha^{-1}) (Table 4). In Augusta, 'Bayou Belle-6' (9,030 kg ha^{-1}) and 'Beauregard-14' (7,466 kg ha^{-1}) had the highest jumbo yield in weed-free conditions. 'Bayou Belle-6' also had the greatest jumbo yield (521 kg ha^{-1}) in weedy plots (Table 5). The greatest losses in jumbo yields are due to the inability of sweetpotato roots to grow to its full size under weed pressure as a result of resource limitation. In previous studies on Palmer amaranth interference in sweetpotato, jumbo grades were reduced the most due to shading caused by Palmer amaranth plants. The reduction of jumbo grades was attributed to a reduction of photosynthate transported to the storage roots (Meyers et al. 2010).

A significant interaction between weeding and cultivar treatments was observed for no. 1 yields in Augusta (*p*=0.0155) (Table 6). In weed-free plots, 'Bayou Belle-6' had the highest no.1 yield (18,683 kg ha^{-1}) followed by 'Heartogold' (13,188 kg ha^{-1}). 'Orleans' and 'Beauregard-14' had the lowest yields in weedy conditions. A cover crop by weeding interaction (*p*=0.0228) was observed for no. 1 yield in Kibler (Table 7). The highest no.1 yield (40,955 kg ha^{-1}) was recorded in plots with cereal rye + crimson clover when maintained weed-free during the sweetpotato growing season. The lowest no. 1 yield (3,938 kg ha^{-1}) was obtained with fallow treatments that were left weedy.

Canner yields differed across weeding ($p \leq 0.0001$) and cultivar treatments ($p \leq 0.0001$) in Augusta (Table 4). With weed interference, canner yield decreased 1,149 kg ha^{-1} when compared to the weed-free treatment (2,546 kg ha^{-1}). 'Heartogold' had the highest canner yield (3,174 kg ha^{-1}), which was similar to 'Bayou Belle-6' (2,016 kg ha^{-1}). 'Orleans' had the greatest canner yield in Kibler, and canner yield was significantly affected by weeding treatments (p=0.006), which ranged from 4,694 to 7,456 kg ha^{-1} with and without weed interference, respectively. The greatest number of cull yields were found with cultivars 'Heartogold' in Kibler and 'Bayou Belle-6' in Augusta.

Total yield in this study was calculated as the sum of jumbo, no.1, and canner yields (Table 8). A significant weeding by cultivar interaction was observed for total yield in Augusta (p=0.0005) and Kibler (p=0.0329). In Augusta, total yield ranged from 2,447 to 8,569 kg ha^{-1} in weedy plots and from 12,158 to 30,328 kg ha^{-1} in weed-free treatment, whereas in Kibler, total yield ranged from 15,978 to 31,949 kg ha^{-1} with weed interference and 41,867 to 70,785 kg ha^{-1} without weed interference. In the absence of weed interference, the most productive cultivar was 'Bayou Belle-6' in Kibler and Augusta. Smith et al. (2021) also reported the high yield potential of this cultivar, where 'Bayou Belle' had 53% and 66% greater marketable yield than 'Covington' and 'NC15-0650', respectively.

The lower yields recorded in Augusta are likely due to the high yellow nutsedge densities encountered in the location. Weed species composition certainly affects the degree of interference, since the competitive ability varies among the species (Clark 1971). Meyers et al. (2015) indicated that yellow nutsedge densities of 5 to 90 shoots meter $^{-2}$ can reduce sweetpotato marketable grades from 18 to 80%. We also speculate that the difference in nutrient levels between the locations contribute to the lower yields in Augusta. Despite of a higher level of phosphorus (P) and potassium (K) encountered in this location, the significant lower levels of micronutrients including calcium (Ca), magnesium (Mg), and sodium (Na) can result in reduced yields. Low levels of micronutrients such as Mg and sulfur (S) are known to cause yield loss in sweetpotato (Halliday and Trenkel 1992). Nevertheless, the higher yields recorded in Kibler can be due to the irrigation supplied throughout the growing season to compensate for lack of rainfall. The experiment in Augusta did not receive complementary irrigation, therefore the water demand may not have been sufficient, especially in September and August, when natural precipitation was low.

Sweetpotato yield was related to vine length and cover crop biomass. A correlation analysis was performed combining data from Augusta and Kibler. The coefficients showed significant correlations between cover crop biomass, vine length, and sweetpotato yields (Table 9). Positive correlations were recorded between vine length and jumbo ($r=0.4734$; $p<0.0001$), no.1 ($r=0.6402$; $p<0.0001$), canner ($r=0.5315$; $p<0.0001$), cull ($r=0.2770$; $p=0.0001$), and total sweetpotato ($r=0.6614$; $p<0.0001$) yields. Nwosisi et al. (2019) reported that yield components in ‘Beauregard’, including marketable yields, number of root tubers, weights, and sizes, are associated to cultivar canopy structure, particularly with length of vines. Furthermore, positive correlations were observed between cover crop biomass and root sizing; jumbo ($r=0.2863$; $p=0.0009$) and no.1 ($r=0.3331$; $p<0.0001$) yields increased with cover crop biomass, resulting in greater total yields ($r=0.3427$; $p<0.0001$). In direct-seeded pumpkins, larger pumpkins were produced in no-till plots, with flail mowed residues of winter wheat and cereal rye compared to bare ground pumpkins (Walters and Young 2010).

Four sweetpotato cultivars were tested in an organic, reduced-tillage system including cereal rye + crimson clover, winter wheat + crimson clover, and fallow treatments. ‘Bayou Belle-

6’ was the top-yielding cultivar in weed-free and maintained the productivity under weedy conditions. Cultivars alone did not differ in their ability in suppressing weeds. The interaction between cultivar and cover crops on weed biomass was significant, suggesting an additive effect. However, this was only observed in Augusta. Cereal rye + crimson clover had superior weed suppression and could therefore result in the reduction of the costs of labor for handweeding. The addition of this cover crop appears to be a better option for growers in terms of improving yields of sweetpotato than winter wheat + crimson clover and without cover crop. A cost benefit analysis of the utilization of this cover crop could assess their profitability to the growers in the long term.

References

Buhler DD (2002) Challenges and opportunities for integrated weed management. Weed Sci 50:273-280.

Burgos NR, Talbert RE (1996) Weed control and sweet corn (*Zea mays* var. rugosa) response in a no-till system with cover crops. Weed Sci 44, 355– 361.

Brennan EB, Smith RF (2005) Winter cover crop growth and weed suppression on the Central Coast of California. Weed Technol 19(4):1017–1024.

Casal JJ (2012) Shade avoidance. Arabidopsis book 10:e0157.

Clark GL (1971) Elementos de Ecologia. Omega, Barcelona. Pp. 534.

Clark A (2007) Managing cover crops profitably. 3rd ed. Sustainable Agriculture Research and Education (SARE) Handbook Series Book 9. College Park, MD: Sustainable Agriculture Research and Education (SARE) Program. Pp 102-135.

Cousens R (1988) Misinterpretations of results in weed research through inappropriate use of statistics. Weed Res 28:281-289.

Davis AS (2010) Cover-crop roller-crimper contributes to weed management in no-till soybean. Weed Sci 58:300-309.

De Laune PB, Mubvumba P, Lewis KL, Keeling JW (2019) Rye cover crop impacts soil properties in a long-term cotton system. Soil Sci Soc Am J 83(5):1451-1458

Finch S (1993) Integrated pest-management of the cabbage root fly and the carrot fly. Crop Prot 12, 423-430.

Haley J, and Curtis J (2006) Sweetpotato grower survey report of results for 2005 crop. Risk Avoidance and Mitigation Program (RAMP): Development of grower decision management tools to reduce risk and enhance sustainability of Southern sweetpotato pest management systems. U.S. Department of Agriculture.

Halliday DJ, Trenkel ME (1992) IFA World Fertilizer Use Manual. Paris, France: International Fertilizer Industry Association. Pp. 142.

Harrison Jr HF, Jackson DM (2011) Response of Two Sweet Potato Cultivars to Weed Interference. Crop Prot 30:1291-1296.

Haynes RJ, Tregurtha R (1999) Effects of increasing periods under intensive arable vegetable production on biological, chemical and physical indices of soil quality. Biol Fertil Soils 28: 259-266.

Kaluwasha W, Kremer RJ, Mihail JD, Lin M, Xiong X (2019) Use of Cover Crops in Organic Sweetpotato Production to Improve Yield: A Case Report. Mod Concep Dev Agrono 4(5).

Keene CL, Moyer JW (2013) Overcoming weed management challenges in cover crop-based organic rotational no-till soybean production in the eastern United States. Weed Technol 27:193-203.

La Bonte DR, Harrison HF, Motsenbocker CE (1999) Sweetpotato clone tolerance to weed interference. HortScience 34:229–232.

La Hovary C, Danehower DA, Ma G, Reberg-Horton C, Williamson JD, Baerson SR, Burton JD (2016) Phytotoxicity and Benzoxazinone concentration in field grown cereal rye (*Secale cereale* L.). In J Agron 1687-8159.

Len Main J (2017) The effects of cover crops and tillage method on sweetpotato [*Ipomoea Batatas* (L.) Lam.] in North Mississippi. Master’s thesis. Starkville, MS: Mississippi State University.

McKinlay RG, McCreath M, Armstrong G (1996) Undersowing cabbages with clover and its effect on the infestation levels of the cabbage root fly. Pages 122-127 in Proceedings Conference on Integrated control in field vegetable crops. Guitté, France.

Mirsky SB, Ryan MR, Teasdale JR, Curran WS, Reberg-Horton SC, Spargo JT, Wells MS, Meyers SL, Jennings KM, Schultheis JR, Monks DW (2010) Interference of Palmer amaranth (*Amaranthus palmeri*) in sweet potato. Weed Sci 58:119–203.

Meyers SL, Shankle MW (2015) Interference of Yellow Nutsedge (*Cyperus esculentus*) in ‘Beauregard' Sweet Potato (*Ipomoea batatas*). Weed Technol 29(4):854-860.

Monks DW, Jennings KM, Meyers SL, Smith TP, Korres NE (2019) Sweet Potato: Important Weeds and Sustainable Weed Management. Pages 581-596 *in* Weed Control: Sustainability, Hazards, and Risks in Cropping Systems Worldwide. 1st ed. CRC Press.

NOAA. National Centers for Environmental information (2022) Climate at a Glance: County Time Series. https://www.ncdc.noaa.gov/cag/. Accessed: February 28, 2022.

Nwosisi S, Nandwani D, Hui D (2019) Mulch Treatment Effect on Weed Biomass and Yields of Organic Sweetpotato Cultivars. Agron 9(4):190.

Nwosisi S, Illukpitiy P, Nandwani D, Arebi IT, Nwosisi O (2021) Organic and conventional sweetpotato production in the Southeastern of United States: a comparative analysis. Agric Food Secur 10:27.

Power JF (1994) Understanding the nutrient cycling process. J Soil Water Conserv 49:16.

Rice PL, McConnell LL, Heighton LP, Sadeghi AM, Isensee AR, Teasdale JR, Abdul-Baki AA Harman-Fetcho JA, CJ Hapeman (2001) Runoff loss of pesticides and soil: a comparison between vegetative mulch and plastic mulch in vegetable production systems. J Environ Qual 30:1808-1821.

Smith SC (2021) Evaluation of a Rye Cover-Crop System for Weed Control and Sweetpotato Tolerance to Indaziflam. PhD. Dissertation. Raleigh, NC: North Carolina State University.

Teasdale JR, Mohler CL (1993) Light transmittance, soil temperature, and soil moisture under residue of hairy vetch and rye. Agron J 85:673–680.

Teasdale JR, Abdul-Baki AA (1998) Comparison of mixtures vs. monocultures of cover crops for fresh-market tomato production with and without herbicide. HortScience 33: 1163-1166.

Przepiorkowski T, Gorski SF (1994) Influence of rye (*Secale cereale*) plant residues on germination and growth of three triazine-resistant and susceptible weeds. Weed Technol 8: 744–747.

[USDA-NASS] National Agricultural Statistics Service (2020) Certified organic survey, 2019 summary. https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/Organics/ORGANICS.pdf. Accessed: March 20, 2022.

[USDA] United States Department of Agriculture (2005) United States Standards for Grades of Sweetpotatoes. https://www.ams.usda.gov/sites/default/files/media/Sweetpotato_Standard%5B1%5D.pdf .Accessed: December 03, 2021.

Wang K, McSorley R, Gallaher RN, Kokalis-Burelle N (2008) Cover crops and organic mulches for nematode, weed and plant health management. Nematology 10:231–242.

Werle IS, Zanon AJ, Streck NA, Schaedler CE, Barbieri GF, Ulguim A (2021) Technology Levels in Cassava Cultivation Alter Phytosociology of Weeds. HortScience 56:787-794.

Tables and Figures

Table 1. Selected soil chemical property information conducted in Kibler and Augusta, AR, 2021.

Cover crop	pH	P	K	Ca	Mg	S	Na	Fe	Mn	Zn	Cu	B	%N	%C	%LOI
								Augusta, AR							
		---	---	---	---	---	---	mg kg $^{-1}$	---	---	---	---	---	---	
Fallow	6.3	132	185	499	39	7.6	3.8	224	360	2.7	1.2	0.4	0.062	0.626	1.14
Rye + clover	6.4	134	157	578	42	7.0	4.2	227	340	2.5	1.2	0.4	0.051	0.463	1.16
Wheat + clover	6.5	131	115	604	44	7.0	5.2	217	332	2.5	1.2	0.5	0.054	0.519	1.04
								Kibler, AR							
Fallow	7.0	97	88	898	171	5.0	15.7	214	79	1.8	1.0	0.4	0.034	0.289	2.23
Rye + clover	7.0	104	92	924	175	7.0	26.8	206	80	1.7	1.1	0.4	0.033	0.288	0.67
Wheat + clover	6.9	99	87	902	174	5.1	16.3	218	81	1.6	1.0	0.4	0.033	0.275	0.65

The soil tests conducted assessed pH (1:2 v:v soil:water ratio), Mehlich 3 extractable nutrients, P, K, Ca, Mg, S, Na, Fe, Mn, Zn, Cu, and B, total nitrogen (N), total carbon (C), and organic matter via loss on ignition (LOI). Soil samples were collected at 15 weeks after transplanting (WAT) in both location sites.

Table 2. Relative frequency (RF), relative density (RD), relative abundance (RAb), and importance value index (IVI) at 5 and 8 weeks after sweetpotato transplanting (WAT) in Kibler and Augusta, AR, 2021.

Weed species	Family	Type	RF (%)	RD (%)	RAb (%)	IVI (%)	RF (%)	RD (%)	RAb (%)	IVI (%)
			5 WAT				8 WAT			
			Augusta, AR							
Alternanthera philoxeroides	Amaranthaceae	broadleaf	9	2	5	17	0	0	0	0
Amranthus palmari	Amaranthacea	broadleaf	0	0	0	0	2	1	0	3
Chamaesyce supina	Euphorbiaceae	broadleaf	1	0	1	2	1	0	0	1
Cynodon dactylon	Poaceae	grass	5	2	7	14	6	4	9	19
Cyperus esculentus	Cyperaceae	sedge	27	55	39	122	26	56	48	130
Digitaria sanguinalis	Poaceae	grass	0	0	0	0	3	0	0	3
Eclipta erecta	Asteraceae	broadleaf	17	11	10	38	23	22	19	65
Euphorbia humistrata	Euphorbiaceae	broadleaf	1	0	0	1	2	0	1	3
Mollugo verticillata	Molluginaceae	broadleaf	6	4	9	19	11	8	10	29
Oenothera laciniata	Onagraceae	broadleaf	14	4	6	24	12	2	4	18
Polygonum arenastrum	Polygonaceae	broadleaf	10	18	20	48	0	0	0	0
Urochloa platyphylla	Poaceae	grass	9	3	3	15	14	7	8	29
			Kibler, AR							
Alternanthera philoxeroides	Amaranthaceae	broadleaf	3	2	3	16	0	0	0	0
Amranthus palmeri	Amaranthacea	broadleaf	7	8	19	55	5	3	0	22
Bidens spp.	Asteraceae	broadleaf	4	4	7	25	2	1	0	7
Cynodon dactylon	Poaceae	grass	1	1	3	8	4	3	0	18
Cyperus esculentus	Cyperacea	sedge	0	0	0	0	1	1	0	4
Digitaria sanguinalis	Poaceae	grass	0	0	0	0	2	4	0	14
Echinochloa colona	Poaceae	grass	0	0	0	0	2	5	0	12
Echinochloa crus-galli	Poaceae	grass	1	1	3	8	0	0	0	0
Eclipta erecta	Asteraceae	broadleaf	2	4	0	12	11	13	0	56
Eleusine indica	Poaceae	grass	9	4	9	48	15	20	26	105
Euphorbia humistrata	Euphorbiaceae	broadleaf	0	0	0	0	1	1	0	4
Leptochloa fusca	Poaceae	grass	0	0	0	0	16	28	0	93
Mollugo verticillata	Molluginaceae	broadleaf	17	77	73	219	2	1	0	7
Oenothera laciniata	Onagraceae	broadleaf	4	3	10	29	6	6	0	31
Secale cereale	Poaceae	grass	7	31	61	120	0	0	0	0
Trifolium incarnatum	Fabaceae	broadleaf	28	141	86	338	16	56	57	178
Triticum aestivum	Poaceae	grass	16	124	127	316	0	0	0	0
Urochloa platyphylla	Poaceae	grass	1	0	0	5	2	2	0	11

Table 3. Effect of cover crops and sweetpotato cultivars on weed biomass (g m^{-2}) in Augusta and Kibler, AR, 2021.

Cover crop	Cultivar	Location	
		Augusta	Kibler
Wheat + clover	Orleans	380 ab	259 NS
	Heartogold	234 d	230
	Bayou Belle-6	259 bd	170
	Baeaureagrd-14	195 d	539
Rye + clover	Orleans	212 d	192
	Heartogold	232 d	371
	Bayou Belle-6	290 abcd	178
	Baeaureagrd-14	223 d	465
Fallow	Orleans	283 abcd	284
	Heartogold	258 cd	315
	Bayou Belle-6	234 d	235
	Baeaureagrd-14	372 ac	259

Means followed by the same letter in a column do not differ significantly according to a Student’s t-test at 5% level of probability.
NS= non-significant.

Table 4. Cover crop, weeding, and cultivar main effects and interactions on sweetpotato yield (kg ha^{-1}) by grade in Augusta and Kibler, AR,2021.

Treatment	Jumbo		No. 1		Canner		Cull		Total yield[1]	
	Augusta	Kibler	Augusta	Kibler	Augusta	Kibler	Augusta	Kibler	Augusta	Kibler
Cover crop										
Wheat + clover	2,368	5,388	7,713	21,605	2,065	6,384	733	2,490	12,146	40,921
Rye + clover	3,652	6,552	8,290	31,271	2,262	6,701	975	2,536	14,204	55,517
Fallow	2,073	3,921	7,161	17,187	1,589	5,141	709	2,060	10,823	32,105
Weeding										
Weeded	5,192	8,468	12,237	32,731	2,546	7,456	822	2,626	19,975	61,047
Weedy	204	1,165	3,206	13,978	1,397	4,694	790	2,098	4,807	24,657
Cultivar										
Beauregard-14	3,753	5,546	5,255	24,388	1,424	5,533	569	1,735	10,432	45,426
Bayou Belle-6	4,775	7,979	11,234	30,815	2,016	5,965	709	2,752	18,025	55,758
Heartogold	897	5,797	9,591	20,632	3,174	5,141	1,431	2,405	13,662	39,443
Orleans	1,366	1,833	4,805	17,583	1,272	7,663	516	2,555	7,443	30,762
Contrast										
Cover crop vs wedding	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Weeding vs cover crop	NS	NS	NS	***	NS	NS	NS	NS	NS	NS
Cover crop vs cultivar	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Weeding vs cultivar	***	NS	***	NS	NS	NS	***	NS	***	***
Cover crop vs wedding vs cultivar	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1] Total marketable is the aggregate of jumbo, no. 1, and canner grades.

***= significant interaction at 5% level of probability.

NS= non-significant.

Table 5. Sweetpotato jumbo yield (kg ha^{-1}) across cultivars in weedy and weed-free conditions in Augusta, AR, 2021.

Weeding	Cultivar	Jumbo yield (kg ha^{-1})
Weeded	Beauregard-14	7,466 a
	Bayou Belle-6	9,030 a
	Heartogold	1,575 b
	Orleans	2,696 b
Weedy	Beauregard-14	40 b
	Bayou Belle-6	521 b
	Heartogold	219 b
	Orleans	35 b

Means followed by the same letter in a column do not differ significantly according to a Student’s t-test at 5% level of probability.

Table 6. Sweetpotato no.1 yield (kg ha^{-1}) across cultivars in weedy and weed-free conditions in Augusta, AR, 2021.

Weeding	Cultivar	No. 1 yield (kg ha^{-1})
Weeded	Beauregard-14	9,358 bc
	Bayou Belle-6	18,683 a
	Heartogold	13,188 b
	Orleans	7,718 cd
Weedy	Beauregard-14	1,151 e
	Bayou Belle-6	3,785 de
	Heartogold	5,994 cde
	Orleans	1,893 e

Means followed by the same letter in a column do not differ significantly according to a Student’s t-test at 5% level of probability.

Table 7. Sweetpotato no.1 yield (kg ha^{-1}) across cover crop treatments in weedy and weed-free conditions in Kibler, AR, 2021.

Weeding	cover crop	No. 1 yield (kg ha^{-1})
Weeded	Wheat + clover	26,801 bc
	Rye + clover	40,955 a
	Fallow	30,437 b
Weedy	Wheat + clover	16,409 d
	Rye + clover	21,587 cd
	Fallow	3,938 e

Means followed by the same letter in a column do not differ significantly according to a Student’s t-test at 5% level of probability.

Table 8. Sweetpotato total yield (kg ha^{-1}) across cultivars in weedy and weed-free conditions in Kibler and Augusta, AR, 2021.

Weeding	Cultivar	Augusta	Kibler
		-----------------kg ha^{-1}-----------------	
Weed-free	Beauregard-14	18,848 b	60,433 b
	Bayou Belle-6	30,328 a	70,785 a
	Heartogold	18,576 b	51,331 b
	Orleans	12,158 c	41,867 c
Weedy	Beauregard-14	2,498 d	20,173 e
	Bayou Belle-6	6,177 cd	31,949 cd
	Heartogold	8,569 c	23,402 de
	Orleans	2,447 d	15,978 e

Total marketable is the aggregate of jumbo, no. 1, and canner grades.

Means followed by the same letter in a column do not differ significantly according to a Student’s t-test at 5% level of probability.

Table 9. Pearson's Correlation assessing the relationship between any two variables.

Variable	by Variable	Correlation	Signif Prob
Cover crop biomass	Jumbo	0.2863	0.0009*
Cover crop biomass	No.1	0.3331	<.0001*
Cover crop biomass	Canner	0.1314	0.1331
Cover crop biomass	Cull	0.1412	0.1063
Cover crop biomass	Total yield	0.3427	<.0001*
Canopy height	Jumbo	-0.0025	0.973
Canopy height	No.1	-0.0446	0.5386
Canopy height	Canner	0.021	0.7729
Canopy height	Cull	0.1125	0.1203
Canopy height	Total yield	-0.0355	0.6297
Vine length	Jumbo	0.4734	<.0001*
Vine length	No.1	0.6402	<.0001*
Vine length	Canner	0.5315	<.0001*
Vine length	Cull	0.277	0.0001*
Vine length	Total yield	0.6614	<.0001
Weed biomass	Jumbo	0.0321	0.8129
Weed biomass	No.1	-0.0233	0.8636
Weed biomass	Canner	0.1381	0.3056
Weed biomass	Cull	-0.0639	0.6365
Weed biomass	Total yield	0.0153	0.9123

*= significant correlation at 5% level of probability.

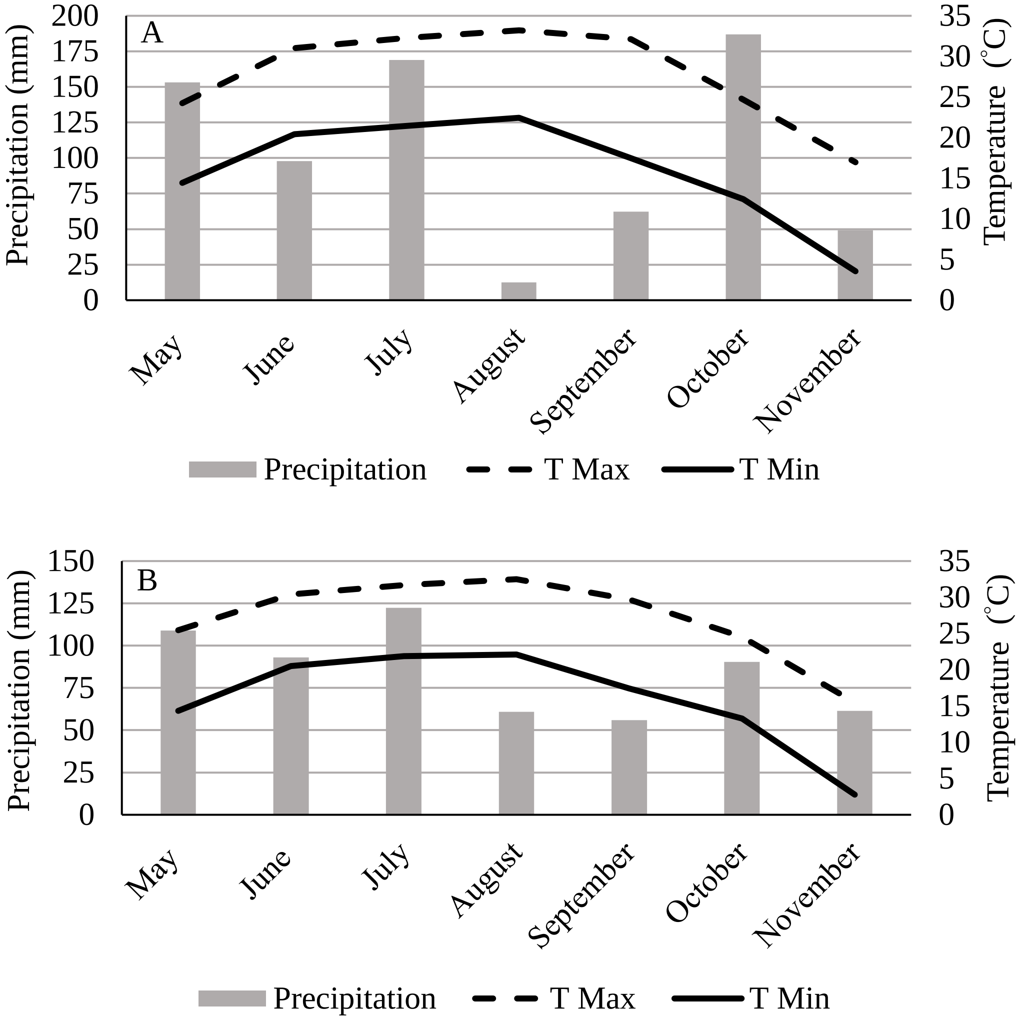

Figure 1. Monthly precipitation (mm), minimum temperature (°C), and maxium temperature (°C) in Kibler (A) and Augusta (B), AR, 2021.

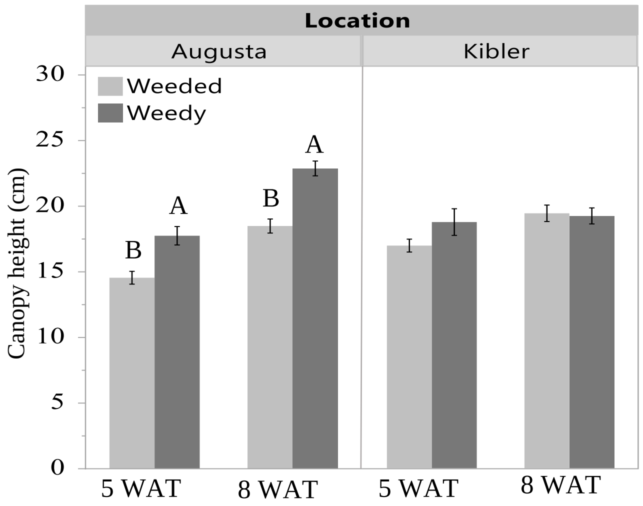

Figure 2. Sweetpotato canopy height averaged across cultivars in weed-free and weedy conditions at 5 and 8 weeks after transplanting (WAT) in Augusta and Kibler, AR, 2021. Means that do not share the same letter are significantly different from each other within location and within evaluation time (p≤0.05). Bars represent standard error.

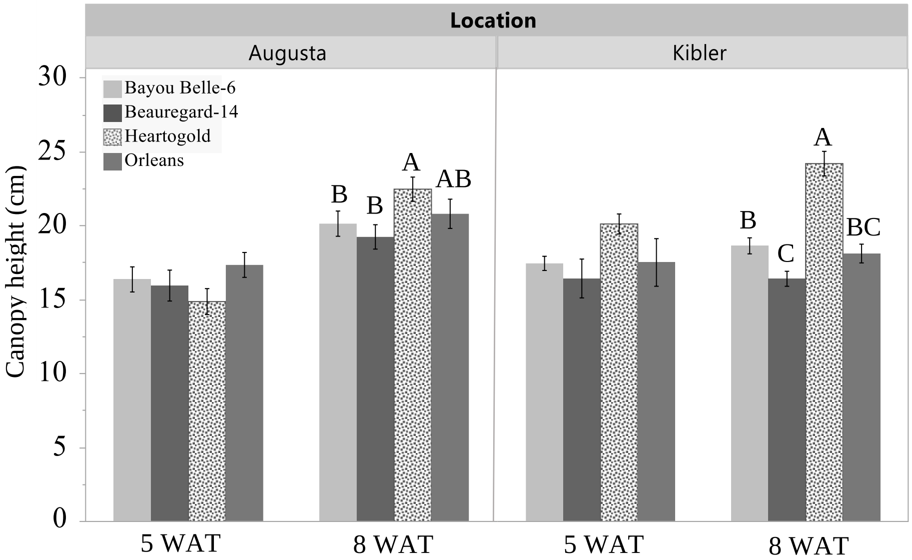

Figure 3. Sweetpotato canopy height at 5 and 8 weeks after transplanting (WAT) in Fayetteville and Kibler, AR, 2021. Means that do not share the same letter are significantly different from each other within location and within evaluation time (p≤0.05). Bars represent standard error.

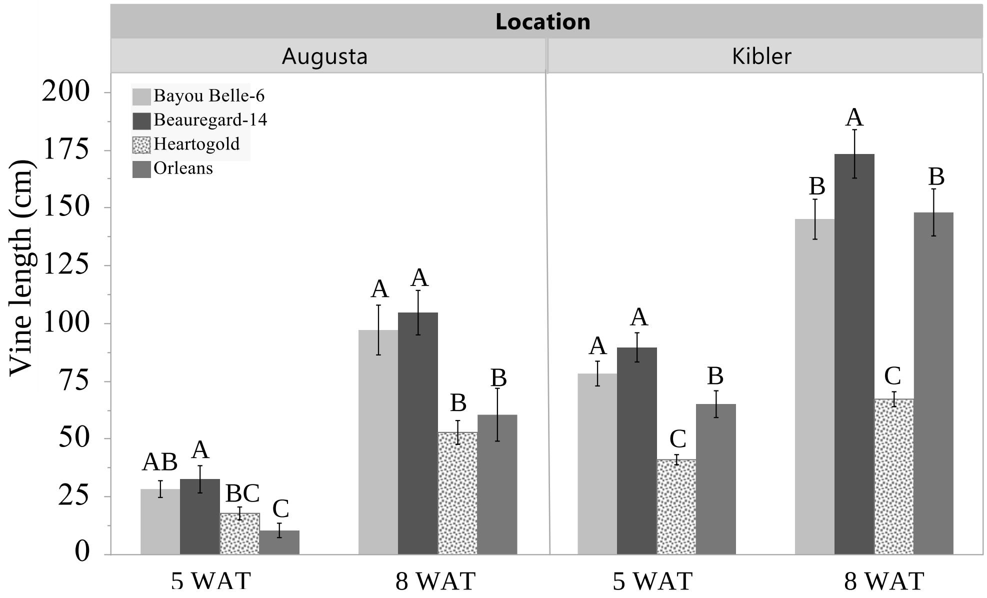

Figure 4. Sweetpotato vine length at 5 and 8 weeks after transplanting (WAT) in Fayetteville and Kibler, AR, 2021. Means that do not share the same letter are significantly different from each other within location and within evaluation time (p≤0.05). Bars represent standard error.

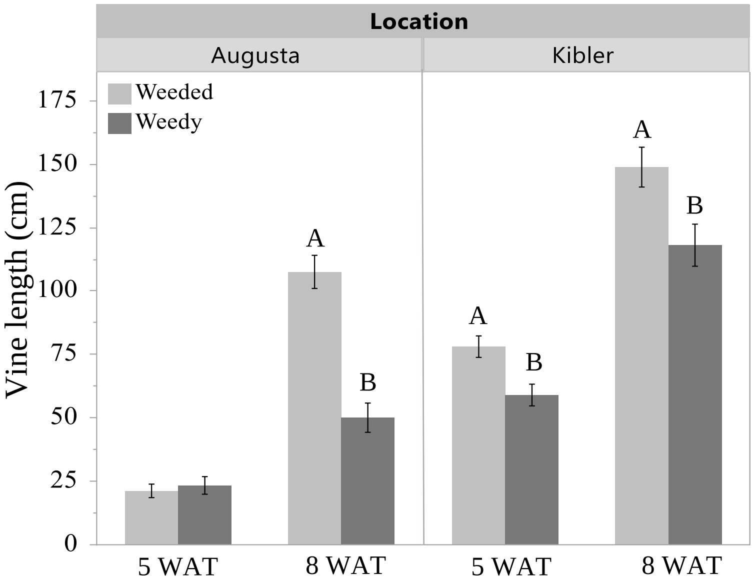

Figure 5. Sweetpotato vine length at 5 and 8 weeks after transplanting (WAT) in Fayetteville and Kibler, AR, 2021. Means that do not share the same letter are significantly different from each other within location and within evaluation time (p≤0.05). Bars represent standard error.

Conclusion

This research investigated the benefits of cultivar selection and cover crops use as tools for integrated weed management in sweetpotato production. ‘Heartogold’, ‘Centennial’, and ‘Stokes Purple’ show allelopathic effect in greenhouse experiments. The primary effect of sweetpotato leachates was observed on height and biomass reduction of junglerice; minimal effect was observed on growth of the broadleaf species, Palmer amaranth and hemp sesbania. In field experiments, ‘Heartogold’ was strongly weed suppressive for both grass spp. and broadleaf spp.. ‘Hatteras’, ‘Centennial’, and ‘Heartogold’ provided significant suppression of yellow nutsedge growth. These three cultivars have short vines and upright growth. Vine length is negatively correlated to weed suppression. Cultivars with long vines, spreading growth habit are poor competitors in the field. Higher LAI and taller sweetpotato canopy do not enhance weed suppression.

In the reduced-tillage, organic system, cover crops reduce weed growth up to 12 WAT. Cereal rye + crimson clover suppresses weeds better than winter wheat + crimson clover. Cover crop biomass, sweetpotato vine length and LAI were positively correlated with jumbo, no.1, canner yields, and total storage root yields. The predominant weed species is a strong determinant of sweetptoato yield. ‘Beauregard-14’ and ‘Bayou Belle-6’ produce the most among the cultivars tested with or without full-season interference of broadleaf or grass spp.. ‘Bayou Belle-2’, ‘Bayou Belle-6’, ‘Hatteras’, and ‘Centennial’ yielded the most in weed-free plots and with yellow nutsedge interference. In the organic, reduced-till experiment, ‘Bayou Belle-6’ had the highest yield. The high yielding cultivars in this test are not allelopathic nor weed suppressive. The ability to maintain high yields without impacting weed fitness suggest that these cultivars have a higher tolerance to weed competition.

Planting fall cover crops such as cereal rye + crimson clover is a good option for weed reduction. Cover crops can enhance sweetpotato yield. The most weed-suppressive cultivars are not always the highest yielding cultivars. To optimize productivity, growers need to understand cultivar competitiveness or ability to suppress or tolerate weeds and adjust the intensity of weed management accordingly. If possible, growers should use weed-suppressive or weed-tolerant cultivars as a part of an integrated weed management program. For example, ‘Heartogold’, an intermediate yielder, but highly weed-suppressive cultivar, would be the best option for highly weed-infested fields, especially for organically grown sweetpotato. ‘Beauregard-14’ and ‘Bayou Belle-6’ could be planted in fields that have more potential for grass or broadleaf annual weeds and would perform better on fields with sufficient cover crop residues. ‘Hatteras’ would be the best cultivar in fields infested with yellow nutsedge. All these factors should be considered before making a cultivar selection. Efforts to identify cultivars with weed-suppressive traits, and agronomic practices that can be improve integrated weed management in sweetpotato production should continue.