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Research Article
Allelopathic Effects of Three Sweet Potato Cultivars (*Ipomoea batatas*) on the Invasive Plant *Mikania micrantha*

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Abstract

Background and Objectives: Sweet potato [*Ipomoea batatas* (L.) Lam] is an important locally grown cash crop in China; it was demonstrated to suppress the invasive plant *Mikania micrantha* (*M. micrantha*) H.B.K through strong competitiveness, but its allelopathic effects on this weed were unknown. The present study aimed to explore the allelopathic potential of sweet potato on *M. micrantha*. **Materials and Methods:** The allelopathic effects of water extracts and soil incorporation from leaves of three sweet potato cultivars (SP1, SP0 and SP9) on the sprout seedling growth of invasive plant *M. micrantha* in Yunnan Province, China, were studied under laboratory and greenhouse conditions. **Results:** Stem length, root biomass, aboveground biomass and total biomass of *M. micrantha* were significantly reduced with increasing concentration in both leaf water extracts and leaf soil incorporation of three sweet potato cultivars. Among these, SP1 had the strongest inhibition and the next highest impact was from SP0 with the lowest effect from SP9. The highest inhibition rates were seen for root biomass, followed by total biomass, whereas the lowest impact was on aboveground biomass. The strong correspondence between results for both leaf water extracts and leaf soil incorporation provided a good demonstration that compounds produced by sweet potato have allelopathic effects on *M. micrantha*. The general inhibition of *M. micrantha* by sweet potato followed the order among the three sweet potato cultivars tested as SP1, SP0 and SP9. Moreover, the synthetical allelopathic indices of leaf soil incorporation of three cultivars on *M. micrantha* were generally higher than these of leaf water extracts. **Conclusion:** Competition and allelopathy have primarily been seen as separate ecological weed management tools, but as these have demonstrated in the case of sweet potato where both mechanisms inhibit weed growth, there is potential for synergism between competition and allelopathy in the reduction of weed infestations.

Key words: Sweet potato, allelopathic effects, *Mikania micrantha*, root biomass, synthetic allelopathic indices

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Biological invasion has received increasing attention in recent decades. The spread of invasive alien species has caused serious economic losses, ecological and environmental problems, biodiversity losses and has even threatened human health and safety[1-3]. Frequently invasive alien species exhibit competitive advantages over native species due to allelopathic properties and establish near monocultures in invaded ecosystems[4,5]. Thus, development of management systems involving native plants or crops that can overcome the allelopathic and competitive effects of invasive alien species has become a major research focus worldwide.

Mikania micrantha H.B.K. (Asteraceae), a perennial herb or semi-woody vine, is native to Central and South America[6]. The vine has been listed among the top 100 worst invasive species and as one of the top 10 worst weeds in the world[6,7]. *M. micrantha* is now present as an invasive species in tropical Asia, parts of Papua New Guinea, Australia, Indian Ocean islands, Pacific Ocean islands and Florida in the U.S.[7,8]. It has colonized a broad range of farming systems and forest lands, banks of streams and rivers, roadsides and railway tracks, pastures and open disturbed areas[6]. In invaded habitats, due to its rapid growth, vegetation smothering habit and release of allelopathic chemicals, *M. micrantha* has caused serious economic loss, biodiversity loss and negative environmental impacts[6,9-11].

To explore ecological methods for managing *M. micrantha*, biological control measures through replacement control with high value species (e.g., local food, native species and/or cash crops) have been surveyed[12-14]. Sweet potato [*Ipomoea batatas* (L.) Lam.: Convolvulaceae], an important locally grown cash crop native to the American tropics, was observed to inhibit *M. micrantha* growth in Longchuan County of Yunnan Province, China in sweet potato fields where *M. micrantha* occurred[14]. Subsequent studies found that sweet potato exhibited greater competitive ability than *M. micrantha*, with plant height, branch, leaf, stem node, adventitious root and biomass of *M. micrantha* suppressed significantly, furthermore sweet potato also demonstrated higher levels of nutrient uptake than *M. micrantha*[15,16]. Flowering phenology of *M. micrantha* was delayed, duration of flowering and fruiting was reduce and duration of bud formation was increased with increasing proportions of sweet potato. The pollinator visits decreased as sweet potato increased[17]. Moreover, the number, biomass, length, set rate, germination of seeds, sexual and asexual seedling populations and mortality of *M. micrantha* were significantly suppressed by sweet potato competition[17]. However it is not clear whether the effective control of sweet potato on *M. micrantha* is solely due to its strong competitive ability, allelopathy, or the interaction of competition and allelopathy.

To complement former studies conducted in the same setting[14,16,17], the present research examined the allelopathic effects of three sweet potato cultivars (SP1, SP0 and SP9) on *M. micrantha* in Yunnan Province, China. These findings were important to further elucidate the mechanisms of interactions between sweet potato and *M. micrantha* and provide a scientific basis for controlling invasion of *M. micrantha* by using sweet potato.

MATERIALS AND METHODS

Study species: *Mikania micrantha* is one of the most serious invasive alien species in Dehong Prefecture of Yunnan Province, China[10]. This plant was collected from a population in Longchuan County of Dehong Prefecture and grown at the greenhouse of the Agricultural Environment and Resource Research Institute, Yunnan Academy of Agricultural Sciences (YAAS), Kunming, China since 2010.

Sweet potato is one of the main food and cash crops in tropical and subtropical regions of Yunnan Province[14]. Three different sweet potato cultivars (SP1, SP0 and SP9) were provided by the Agricultural Environment and Resource Research Institute, Yunnan Academy of Agricultural Sciences (YAAS), China. Because some cultivars are still at an early stage in the breeding and commercial development process, the product names are not provided here. Preliminary field and laboratory studies have confirmed that different sweet potato cultivars exhibit variation in competitive ability and growth characteristics.

Leaf water extraction procedure: Fresh leaves (100 g) of each sweet potato cultivar were collected from the greenhouse of Agricultural Environment and Resource Research Institute, YAAS, Kunming, China on July 17, 2016. Leaf samples were cleaned with distilled water and then cut into pieces (approximately 1-5 mm) for extraction of compounds. Each sample was placed in a conical flask and distilled water was added (1 L for leaves). Extracts were prepared at room temperature (18-20°C) and kept in the dark for 24 h before filtering through two layers of cheese cloth, two layers of filter paper and then through a 0.45 μm microporous membrane. The filtered liquid served as the initial aqueous extract, each type of initial aqueous extract was diluted with distilled water to four concentrations: 0.0125, 0.025, 0.05 and 0.1 g mL^{-1} and stored at 4°C prior to use.

Leaf incorporated in soil procedure: Fresh leaves (1500 g) of each sweet potato cultivar were collected from the greenhouse of Agricultural Environment and Resource Research Institute, YAAS, Kunming, China on July 17, 2016. Leaf samples were cleaned with distilled water and then were chopped into approximately 1-5 mm pieces. Each sample (18.75, 37.5, 75, 150 g fresh weight) was placed in a plastic box (22×13×7 cm) and soil was added to achieve a total weight of the mixture of 1500 g. The leaf material and soil were mixed evenly and consisted of four concentrations: 0.0125, 0.025, 0.05 and 0.1 g g^{-1} and stored in the greenhouse prior to use.

Extract bioassays: Amber wide-mouth glass packer bottles (150 mL) were used for seedling growth assays. To ensure relative uniformity among the experimental stock, one-node segments (fresh weight 0.3-0.4 g, 5-6 cm pieces) were taken from central stem portions of relatively young *M. micrantha* plants of similar size. On 19 July, 2016, three sprouts for each replicate derived from cuttings of *M. micrantha* were evenly placed in a glass packer bottle after covered with fresh plastic film and 100 mL extract or distilled water (control) was added. Glass packer bottles were placed in an incubator with the following growth conditions: 20°C, 12 h dark/25°C, 12h light. Experiments were carried out in 4 replicates for each concentration of each extract and enough extract or distilled water (control) was added to each glass packer bottle as necessary during incubation. Plant height, fresh root weight, aboveground weight and total biomass of *M. micrantha* were recorded after 30 days of incubation.

Simultaneously, the leaves incorporated in the soil experiments were conducted in a greenhouse at the Agricultural Environment and Resource Research Institute, YAAS. On 19 July, 2016, six sprouts derived from cuttings of *M. micrantha* were prepared and evenly transplanted into a plastic box (22×13×7 cm) with soil and leaves mixed. A control treatment without leaves was included. All of the plastic boxes were kept in greenhouse [25-28 with a 12 h/12 h (day/light) photoperiod]. All boxes were arranged in a randomized block design with 4 replications. Thirty days after sowing, plant height, fresh root weight, aboveground weight and total biomass of *M. micrantha* were measured. During the experiments, the plots were regularly weeded and no synthetic fertilizers were used.

Statistical analysis: The response index[18], IR was calculated using the formula: 1-C/T (if T≥C) or T/C-1 (if T<C), where C is the mean value of control and T is the mean value of each extract treatment, IR>0 indicates promotion, IR<0 indicates inhibition and the magnitude of IR values reflects the intensity of the allelopathic effect. The synthetical allelopathic index was calculated using the mean value of IR values of plant height, root weight, aboveground weight and total weight. Data were analyzed by analysis of variance (one-way ANOVA). If significant differences were detected by ANOVA, Duncan's multiple range tests were used to detect differences among treatments at a 5% level of significance.

RESULTS

Effects of sweet potato on plant height of *M. micrantha*: The three sweet potato cultivars tested (SP1, SP0 and SP9) results in varying effects on the stem length of *M. micrantha* (Table 1 and 2). In both leaf water extracts and leaf incorporated soil of three cultivars, the inhibition was increased markedly with increasing concentration. SP1 produced the strongest inhibition, with suppression rates of 47.40 and 5.10% at concentrations 0.1 and 0.0125 g mL^{-1} for water extract, 40.12 and 27.44% at concentrations 0.1 and 0.0125 g g^{-1} for soil incorporation, respectively (Table 1 and 2). For SP0 with soil incorporation, the stem length of *M. micrantha* was significantly reduced with increasing concentration, but was significantly increased at concentrations 0.025 and 0.0125 g mL^{-1} in water extracts of sweet potato leaf. With just a few exceptions SP9 treatments results in longer stem lengths of *M. micrantha*, ranging to as much as 25.75 and 14.71% higher than the control at concentrations 0.0125 g mL^{-1}/g g^{-1} in both leaf water extract and leaf incorporated soil, respectively (Table 1 and 2).

Effects of biomass of *M. micrantha* by sweet potato: Root biomass, above ground biomass and total biomass of *M. micrantha* were significantly reduced with increasing concentration of leaf water extracts and leaf soil incorporation of three sweet potato cultivars for the most part. The SP1 cultivar most strongly inhibited the biomass of *M. micrantha*, with suppression of root biomass, aboveground biomass and total biomass of *M. micrantha* 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 soil (Table 1 and 2). The next highest inhibition was due to SP0 and the least was seen for SP9. The highest inhibition rates were seen for root biomass, with suppression rates ranging from 20.13-98.15% at concentrations 0.0125-0.1 g mL^{-1}/g g^{-1}, followed by total biomass and the lowest impact was on the aboveground biomass (Table 1 and 2).

Table 1: Effects of water extract of sweet potato leaves on stem length, root biomass, aboveground biomass and total biomass of *Mikania micrantha*

	Concentration (g mL^{-1})	SP1	SP0	SP9
Stem length (cm)	0.1	6.825±0.250^{e}	8.175±0.512^{d}	9.075±1.071^{b}
	0.05	7.750±0.370^{d}	12.625±0.378^{c}	11.925±0.419^{a}
	0.025	9.575±0.486^{c}	19.325±0.403^{a}	12.025±0.457^{a}
	0.0125	12.313±0.371^{b}	18.125±0.330^{b}	12.575±0.680^{a}
	CK	12.975±0.411^{a}	12.875±0.737^{c}	10.000±0.535^{b}
Root biomass (g)	0.1	0.006±0.008^{d}	0.019±0.013^{d}	0.005±0.010^{e}
	0.05	0.044±0.002^{c}	0.180±0.004^{c}	0.095±0.003^{d}
	0.025	0.183±0.014^{b}	0.188±0.003^{c}	0.116±0.003^{c}
	0.0125	0.196±0.008^{b}	0.249±0.014^{b}	0.127±0.004^{b}
	CK	0.324±0.009^{a}	0.314±0.006^{a}	0.159±0.003^{a}
Aboveground biomass (g)	0.1	0.463±0.028^{e}	0.553±0.009^{e}	0.643±0.015^{d}
	0.05	0.515±0.035$_{d}$	0.926±0.018^{c}	0.970±0.027^{a}
	0.025	0.710±0.008^{c}	1.032±0.067^{b}	0.930±0.024^{b}
	0.0125	1.020±0.023^{b}	1.301±0.007^{a}	0.909±0.016^{b}
	CK	1.138±0.015^{a}	0.807±0.013^{d}	0.703±0.014^{c}
Total biomass (g)	0.1	0.469±0.035^{e}	0.571±0.019^{d}	0.648±0.021^{c}
	0.05	0.559±0.034^{d}	1.105±0.019^{c}	1.065±0.026^{a}
	0.025	0.893±0.014^{c}	1.219±0.070^{b}	1.045±0.021^{a}
	0.0125	1.216±0.029^{b}	1.550±0.013^{a}	1.036±0.019^{a}
	CK	1.462±0.018^{a}	1.121±0.015^{c}	0.863±0.013^{b}

Data are expressed as Mean±Standard deviation. Different letters within same column represent significant differences at p<0.05

Table 2: Effects of leaf incorporated soil of sweet potato on stem length, root biomass, aboveground biomass and total biomass of *Mikania micrantha*

	Concentration (g g^{-1})	SP1	SP0	SP9
Stem length (cm)	0.1	7.200±0.294^{d}	7.550±0.289^{d}	7.075±0.222^{c}
	0.05	8.300±0.294^{bc}	9.250±0.342^{c}	9.050±0.370^{b}
	0.025	7.900±0.245^{c}	10.950±0.342^{b}	10.175±0.499^{a}
	0.0125	8.725±0.171^{b}	10.700±0.365^{b}	10.725±0.403^{a}
	CK	12.025±0.386^{a}	11.525±0.222^{a}	9.350±0.342^{b}
Root biomass (g)	0.1	0.052±0.002^{e}	0.420±0.011^{d}	0.384±0.005^{e}
	0.05	0.322±0.010^{c}	0.656±0.007^{c}	0.700±0.010^{d}
	0.025	0.236±0.005^{d}	0.857±0.019^{a}	1.028±0.028^{a}
	0.0125	0.408±0.013^{b}	0.795±0.006^{b}	0.991±0.026^{b}
	CK	0.829±0.006^{a}	0.813±0.012^{a}	0.760±0.013^{c}
Aboveground biomass (g)	0.1	0.718±0.012^{d}	1.084±0.049^{c}	0.657±0.019^{c}
	0.05	1.225±0.017^{b}	1.235±0.017^{b}	1.399±0.013^{b}
	0.025	1.093±0.040^{c}	1.277±0.022^{b}	1.744±0.076^{a}
	0.0125	1.252±0.034^{b}	1.280±0.035^{b}	1.412±0.022^{b}
	CK	1.447±0.039^{a}	1.436±0.032^{a}	1.458±0.015^{b}
Total biomass (g)	0.1	0.770±0.012^{e}	1.504±0.059^{e}	1.042±0.024^{e}
	0.05	1.546±0.013^{c}	1.890±0.020^{d}	2.099±0.019^{d}
	0.025	1.329±0.038^{d}	2.133±0.035^{b}	2.772±0.097^{a}
	0.0125	1.660±0.036^{b}	2.075±0.035^{c}	2.403±0.016^{b}
	CK	2.276±0.044^{a}	2.249±0.035^{a}	2.218±0.011^{c}

Data are expressed as Mean±Standard deviation. Different letters within same column represent significant differences at p<0.05

Allelopathic response of *M. micrantha* to sweet potato: The allelopathic response index and synthetical allelopathic index of three sweet potato cultivars (SP1, SP0 and SP9) on the stem length and biomass of *M. micrantha* differed, depending on the cultivar (Table 3 and 4). All response indices for both water extracts and soil incorporated SP1 leaves on various *M. micrantha* components had negative values and significantly decreased with increasing concentration showing that SP1 extracts significantly inhibited *M. micrantha.* Most response indices for both water extracts and soil incorporated SP0 leaves on various *M. micrantha* components had negative values and significantly decreased with increasing concentration showing that SP0 extracts generally inhibited *M. micrantha.* Only half of the response indices from both water extracts and soil incorporated SP9 leaves on various components of *M. micrantha* had negative values, whereas SP9 extracts significantly inhibited *M. micrantha* at high concentrations, low concentrations promoted *M. micrantha* growth (Table 3 and 4).

The synthetical allelopathic indices for both water extracts (except at concentration 0.0125 g mL^{-1} for SP0) and soil incorporation from SP1 and SP0 leaves exhibited

Table 3: Response index of leaf water extract of sweet potato on *Mikania micrantha*

	Concentration (g mL^{-1})	SP1	SP0	SP9
Stem length	0.1	-0.904±0.116^{d}	-0.580±0.142^{c}	-0.114±0.147^{b}
	0.05	-0.677±0.088^{c}	-0.020±0.055^{b}	0.161±0.035^{a}
	0.025	-0.358±0.083^{b}	0.333±0.045^{a}	0.168±0.052^{a}
	0.0125	-0.054±0.025^{a}	0.290±0.036^{a}	0.203±0.067^{a}
Root biomass	0.1	-12.933±15.511^{a}	-8.918±6.302^{b}	-1.725±3.450^{a}
	0.05	-6.348±0.322^{a}	-0.748±0.063a	-0.677±0.054^{a}
	0.025	-0.781±0.179^{a}	-0.672±0.028^{a}	-0.377±0.044^{a}
	0.0125	-0.657±0.091^{a}	-0.261±0.058^{a}	-0.255±0.045^{a}
Aboveground biomass	0.1	-1.465±0.117^{d}	-0.461±0.034^{d}	-0.095±0.034^{c}
	0.05	-1.217±0.175^{c}	0.128±0.018^{c}	0.275±0.027^{a}
	0.025	-0.602±0.008^{b}	0.215±0.061^{b}	0.243±0.031^{ab}
	0.0125	-0.116±0.012^{a}	0.380±0.011^{a}	0.223±0.008^{b}
Total biomass	0.1	-2.131±0.208^{d}	-0.963±0.068^{d}	-0.333±0.054^{b}
	0.05	-1.622±0.180^{c}	-0.014±0.022^{c}	0.190±0.025^{a}
	0.025	-0.637±0.037^{b}	0.079±0.060^{b}	0.174±0.026^{a}
	0.0125	-0.203±0.024^{a}	0.277±0.014^{a}	0.167±0.007^{a}
Synthetical allelopathic index	0.1	-4.358±3.799^{b}	-2.730±1.534^{b}	-0.567±0.809^{a}
	0.05	-2.466±0.110^{ab}	-0.164±0.034^{a}	-0.013±0.008^{a}
	0.025	-0.595±0.070^{a}	-0.011±0.041^{a}	0.052±0.012^{a}
	0.0125	-0.257±0.030^{a}	0.172±0.017^{a}	0.085±0.016^{a}

Data are expressed as Mean±Standard deviation. Different letters within same column represent significant differences at p<0.05

Table 4: Response index of leaf incorporated soil of sweet potato on *Mikania micrantha*

	Concentration (g g^{-1})	SP1	SP0	SP9
Stem length	0.1	-0.672±0.065^{c}	-0.528±0.057^{c}	-0.322±0.028^{c}
	0.05	-0.451±0.093^{ab}	-0.247±0.052^{b}	-0.035±0.058^{b}
	0.025	-0.524±0.082^{b}	-0.053±0.041^{a}	0.079±0.069^{a}
	0.0125	-0.379±0.063^{a}	-0.078±0.050^{a}	0.127±0.061^{a}
Root biomass	0.1	-15.070±0.547^{d}	-0.935±0.027^{d}	-0.977±0.043^{c}
	0.05	-1.579±0.079^{b}	-0.240±0.018^{c}	-0.086±0.013^{b}
	0.025	-2.519±0.090^{c}	0.051±0.033^{a}	0.261±0.011^{a}
	0.0125	-1.033±0.058^{a}	-0.022±0.008^{b}	0.233±0.020^{a}
Aboveground biomass	0.1	-1.015±0.036^{c}	-0.327±0.062^{b}	-1.221±0.080^{c}
	0.05	-0.182±0.034^{a}	-0.164±0.039^{a}	-0.042±0.017^{b}
	0.025	-0.325±0.045^{b}	-0.125±0.024^{a}	0.163±0.041^{a}
	0.0125	-0.156±0.018^{a}	-0.122±0.008^{a}	-0.033±0.006^{b}
Total biomass	0.1	-1.957±0.038^{d}	-0.496±0.053^{c}	-1.131±0.054^{d}
	0.05	-0.472±0.026^{b}	-0.190±0.030^{b}	-0.057±0.011^{c}
	0.025	-0.714±0.049^{c}	-0.055±0.025^{a}	0.199±0.026^{a}
	0.0125	-0.372±0.020^{a}	-0.084±0.005^{a}	0.077±0.008^{b}
Synthetical allelopathic index	0.1	-4.679±0.145^{d}	-0.571±0.024^{c}	-0.913±0.041^{d}
	0.05	-0.671±0.033^{b}	-0.210±0.022^{b}	-0.055±0.017^{c}
	0.025	-1.020±0.042^{c}	-0.046±0.025^{a}	0.175±0.028^{a}
	0.0125	-0.485±0.008^{a}	-0.077±0.014^{a}	0.101±0.020^{b}

Data are expressed as Mean±Standard deviation. Different letters within same column represent significant differences at p<0.05

negative values and significantly deceased with increasing concentration, further corroborating the significant inhibitory effects of these two cultivars on *M. micrantha* (Table 3 and 4). For SP9, the synthetical allelopathic indices for both water extracts and soil incorporation had negative values only at concentrations 0.1 and 0.05 g mL^{-1}/g g^{-1}, indicating a "low-promotion and high-inhibition effect" on *M. micrantha*. Finally, the synthetical allelopathic indices of leaf soil incorporation on *M. micrantha* were generally higher than these of leaf water extracts (Table 3 and 4). Taken together, the response and synthetical indices indicated that the allelopathic effects of sweet potato cultivars on *M. micrantha* followed the order SP1 SP0 SP9.

DISCUSSION

Sweet potato is one of the main food and cash crops in Yunnan Province and is widely planted in temperate, subtropical and tropical regions in the province. It is also grown in many other regions of China and other subtropical

or warm-temperate regions of the world as a food source[14,16]. This herbaceous perennial vine generally exhibits a prostrate growth form in agricultural areas, so its niche is similar to that of *M. micrantha*. Strong interspecific competition occurs between the two species when grown together[16,17]. The present study demonstrated that sweet potato not only competes strongly for resources with *M. micrantha*, but also exhibits strong allelopathic impacts on *M. micrantha*, although these impacts vary with sweet potato cultivar.

The growth and development of a plant may be affected by allelochemicals at any time during its life cycle, including seed germination, seedling growth, flowering and fruiting stages and eventually lead to inhibition of plant populations[5,19,20]. Due to low seed germination of *M. micrantha* under laboratory conditions, sprout seedlings were selected for testing allelopathic effects in this study. The results show that three sweet potato (SP1, SP0 and SP9) cultivars significantly inhibited plant height, root biomass, aboveground biomass and total biomass of *M. micrantha* and increased with increasing concentration. The highest inhibition rates on *M. micrantha* were seen for root biomass, followed by the total biomass and the least inhibited component measured was aboveground biomass. The inhibition by allelochemicals on root biomass and growth generally causes a reduction in plant root length and number, water absorption ability and fertilizer absorption ability, which reduces the effective utilization of resources and affects later growth and development, status and functions of the species[21,22].

In bioassays for allelopathy, the most commonly used indices are index of response and synthetical allelopathic index[18]. Meanwhile, the effects of response index and synthetical allelopathic index on root length and biomass of the receptor plant tend to be the most important measured indices[18,22-24]. The present study found that both leaf water extracts and leaf soil incorporation from three sweet potato cultivars generally resulted in negative response indices that were magnified at increasing concentrations for stem length, root biomass, aboveground biomass and total biomass of *M. micrantha*. This provide clear evidence for allelopathic inhibition by sweet potato. Moreover, in order to evaluate the comprehensive allelopathic effects of sweet potato on *M. micrantha*, the synthetical allelopathic index of four parameters, stem length, root biomass, aboveground biomass and total biomass, were evaluated in this study. By examining the synthetical allelopathic index of three cultivars in both leaf water extracts and leaf soil incorporation, it is found SP1 had the strongest inhibition followed by SP0 and SP9 creating the least inhibition.

Other research has shown that sweet potato also has allelopathic effects on other plants and crops. Shen *et al.*[25] reported that the water extracts from sweet potato leaves strongly inhibited four major agricultural weeds: *Ageratum conyzoides*, *Bidens pilosa*, *Digitaria sanguinalis* and *Galinsoga parviflora*. Xu *et al.*[12] found that an aqueous extract from the aboveground parts of sweet potato significantly inhibited root and stem length of *M. micrantha*. Moreover, sweet potato also has been shown to have allelopathic effects on other plants such as *Imperata cylindrica*, *Lactuca sativa*, *Cucumis sativus*, *Cyperus rotundus*, *Medicago sativa* and *Vigna unguiculata*[23,24,26-28].

Mikania micrantha has been labelled as both an agricultural and environmental weed. Due to rapid growth, vegetation smothering habit and action of allelopathic chemicals, this weed is prone to establish monotypic stands or at least become dominant in invaded habitats, which causes negative impacts on agricultural production and natural environments[6,9-11]. Sweet potato exhibits prolific asexual reproduction, rapid growth and readily forms extensive canopies in farming systems. Thus, sweet potato not only has considerable potential to control *M. micrantha*, but should also provide an effective ecological management tool for controlling other agricultural weeds. Zhang *et al.*[29] surveyed the weeds in sweet potato fields and found that there were clear differences in weed species at different vegetative growth stages. Shen *et al.*[30] reported that *D. sanguinalis*, *A. conyzoides*, *B. pilosa*, *G. parviflora*, *Portulaca oleracea* and *Eleusine indica* were the dominant species in sweet potato weed communities, but their abundance was significantly reduced with increased sweet potato cover; in particular importance values were negatively correlated with sweet potato cover. Generally, weed suppression via other plant species is determined by competition, allelopathy, or as seldom demonstrated, a combination of the two[20,31,32]. When sweet potato and *M. micrantha* grow together, sweet potato has a competitive advantage in terms of plant growth characteristics and greater absorption of soil nutrients and significantly suppresses the reproductive ability of *M. micrantha*[16,17]. Moreover, this study showed that stem height, root biomass, aboveground and total biomass of *M. micrantha* were significantly inhibited with increasing concentration of water extracts and soil incorporation of sweet potato leaves. Thus, this is a case where both competition and allelopathy work together to suppress weed growth.

CONCLUSION

Competition and allelopathy have primarily been seen as separate ecological tools for weed management, but as we have demonstrated in the case of sweet potato where both mechanisms inhibit weed growth, there is potential for synergism between competition and allelopathy in the reduction of weed infestations.

SIGNIFICANCE STATEMENT

This study discovers sweet potato has pronounced allelopathic effects on the invasive plant *M. micrantha* and the general inhibition of *M. micrantha* by sweet potato followed the order among the three sweet potato cultivars tested as SP1, SP0, SP9. This study will contribute to elucidate the allelopathic competition of sweet potato on other weeds including *M. micrantha.*

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