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Interference of morningglories (*Ipomoea* spp.) with ‘Fascination’ triploid watermelon

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Research Article

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Abstract

Morningglories (*Ipomoea* spp.) are among the most troublesome weeds in cucurbits in the United States; however, little is known about *Ipomoea* spp. interference with horticultural crops. Two additive design field studies were conducted in 2020 at two locations in Indiana to investigate the interference of ivyleaf morningglory (*Ipomoea hederacea* Jacq.), entireleaf morningglory (*Ipomoea hederacea* Jacq. var. *integriuscula* A. Gray.), and pitted morningglory (*Ipomoea lacunosa* L.) with triploid watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai]. Immediately after watermelon was transplanted, *Ipomoea* spp. seedlings were transplanted into the watermelon planting holes at densities of 0 (weed-free control), 3, 6, 12, 18, and 24 plants 27 m^{-2}. Fruit was harvested once a week for 4 wk, and each fruit was classified as marketable (≥4 kg) or non-marketable (<4 kg). At 1 wk after the final harvest, aboveground biomass samples were collected from 1 m^{2} per plot and oven-dried to obtain watermelon and *Ipomoea* spp. dry weight. Seed capsules and the number of seeds in 15 capsules were counted from the biomass sample to estimate seed production. *Ipomoea* spp. densities increasing from 3 to 24 plants 27 m^{-2} increased marketable watermelon yield loss from 58% to 99%, reduced marketable watermelon fruit number 49% to 98%, reduced individual watermelon fruit weight 17% to 45%, and reduced watermelon aboveground biomass 83% to 94%. *Ipomoea* spp. seed production ranged from 549 to 7,746 seeds m^{-2}, greatly increasing the weed seedbank. *Ipomoea* spp. hindered harvest due to their vines wrapping around watermelon fruits. The most likely reason for watermelon yield loss was interference with light and consequently less dry matter being partitioned into fruit development due to less photosynthesis. Yield loss was attributed to fewer fruits and the weight of each fruit.

Introduction

Watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] production in the United States averaged 1.7 billion kg between 2015 and 2019 (Kramer et al. 2020), placing it in the world’s top 10 watermelon-producing countries (FAO 2022). In Indiana, 2,469 ha were harvested in 2019, valued at $35 million (USDA-NASS 2019). Watermelon is usually transplanted into raised beds covered with polyethylene mulch, with a between-row distance of 1.8 to 3.7 m and in-row spacing of 90 to 180 cm (Egel 2020). Watermelon vines start covering between-row areas (row middles) at 3 wk after transplanting (WATr) and fully cover the row middles after 7 WATr (Andino and Motsenbocker 2004). Thus, watermelon is particularly vulnerable to weed competition because of the wide row spacing required for vine growth and its slow initial growth. The high temperatures necessary for watermelon production also enable summer annual weeds to establish.

Adkins et al. (2010) reported that ‘Super Crisp’ triploid watermelon fields must be kept weed-free for 3.6 wk to limit yield losses to 10%. To avoid yield losses above 5%, Bertucci et al. (2019b) reported that ‘Exclamation’ triploid watermelon must be kept weed-free between 2.3 and 2.5 WATr, and ‘Carnivor’ between 1.9 and 2.6 WATr. Weed management strategies for watermelon production involve preemergence and postemergence herbicide applications, raised beds with drip irrigation and polyethylene mulch, in-season cultivation, hand hoeing, and hand weeding. Ideally, watermelon fields should be kept weed-free throughout the growing season or at least during the critical weed-free period. Unfortunately, weed escapes do occur.

Collectively, the summer annual morningglories (*Ipomoea* spp.) were ranked as the fourth most troublesome weeds in the United States and Canada in cucurbits (Van Wychen 2019). The most relevant *Ipomoea* spp. to crops in Indiana are ivyleaf morningglory (*Ipomoea hederacea* Jacq.), entireleaf morningglory (*Ipomoea hederacea* Jacq. var. *integriuscula* A. Gray), pitted morningglory (*Ipomoea lacunosa* L.), and tall morningglory [*Ipomoea purpurea* (L.) Roth].

Ipomoea spp. compete for resources and climb and twine around crops, affecting harvest efficiency and yield. They find, climb, and twine neighboring plants using several mechanisms, including phototropism, circumnutation, and shade-avoidance reactions. *Ipomoea* spp. grow toward other plants due to phototropism, most likely because other plants reflect solar radiation. Their vining habit and circumnutation allow them to twine around these plants (Price and Wilcut 2007). Vines are considered "structural parasites," because they lean on other plants for support, which can cause structural damage (Paul and Yavitt 2011). Finally, because of shade-avoidance reactions, *Ipomoea* spp. grow over other plants. *Ipomoea* spp. are highly competitive organisms because they increase their biomass and thus their seed production the closer they are to other plants (Price and Wilcut 2007). As a result, affected plants grow under stress and often die. Thus, the presence of *Ipomoea* spp. negatively affects yield and harvest and increases the weed seedbank in the soil, intensifying weed competition in subsequent years.

Little is known about the interference of *Ipomoea* spp. with horticultural crops. However, *Ipomoea* spp. interference with soybean [*Glycine max* (L.) Merr.] and cotton (*Gossypium hirsutum* L.) have been studied. In soybean, full-season competition of a single *I. hederacea* plant 15 cm^{-1} reduced yield 13% to 36% (Cordes and Bauman 1984), and 1 *I. purpurea* plant m^{-2} reduced yield by 26% (Pagnoncelli et al. 2017). In cotton, 1 *I. hederacea* var. *integriuscula* plant 10 m^{-1} reduced yield 3% to 7% (Wood et al. 1999), and 1 *I. hederacea* plant 2 m^{-1} reduced yield 11% (Keeley et al. 1986). We hypothesized that the biology of *Ipomoea* spp. allows them to be competitive with susceptible crops such as watermelon and predicted that as *Ipomoea* spp. density increased, watermelon production would decrease. Thus, additive design trials were established to determine the influence of season-long *Ipomoea* spp. interference on plasticulture triploid watermelon.

Materials and Methods

Two additive design studies (Oliveira et al. 2018a) in which crop density was kept constant and *Ipomoea* spp. density was varied were performed in 2020 at the Southwest Purdue Agricultural Center (SWPAC), Vincennes, IN, USA (38.73°N, 87.48°W) and Meigs Horticulture Research Farm (MEIGS), Lafayette, IN, USA (40.28°N, 86.884°W). Soils were a Lomax loam (coarse-loamy, mixed, superactive, mesic Cumulic Hapludolls) with 1.5% organic matter (OM) and pH 6.6 at SWPAC, and a Drummer silty clay loam (fine-silty, mixed, superactive, mesic Typic Endoaquolls) with 4.5% OM and pH 6.5 at MEIGS. 'Fascination' triploid watermelon and 'Wingman' pollenizer watermelon seeds were planted into 50-cell black seedling flats containing a peat-based potting media (Metro-Mix 360, Sun Gro Horticulture, Agawam, MA, USA) in a SWPAC greenhouse on April 20, 2020.

Fields were tilled using a disc plow before the formation of raised beds on April 21 and 28, 2020, at SWPAC and MEIGS, respectively. Each raised bed was covered with black polyethylene mulch and contained a drip tape placed in the middle, near the soil surface for irrigation. Plots were 27 m^2 and consisted of three rows, each 4.9-m long, with a between-row spacing of 1.8 m. Crop fertilization, irrigation, and disease and insect management were maintained according to commercial watermelon-growing recommendations (Egel 2020). After bed formation and before transplanting, *S*-metolachlor (Dual Magnum®, Syngenta Crop Protection, Greensboro, NC, USA) at 1.1 kg ai ha^{-1} at SWPAC and a tank mix of 40 g ha^{-1} halosulfuron-methyl (Sandea®, Canyon Group, Gowan Company, Yuma, AZ, USA) and 1.4 kg ha^{-1} ethalfluralin plus 421 g ha^{-1} clomazone (Strategy®, Loveland Products, Greeley, CO, USA) were applied at MEIGS to manage weeds in row middles. All other weeds that were not part of the experiment were removed from all plots as necessary, either by hand or with hoes or cultivators.

Two weeks before the watermelon transplanting date at each location, *Ipomoea* spp. seeds were planted into 72-cell trays containing a peat-based potting media (Berger BM2 Seed Germination Mix, Hummert International, Earth City, MO, USA) at the Purdue University Horticulture Greenhouses, West Lafayette, IN, USA. *Ipomoea* spp. seeds (Azlin Seed Service, Leland, MS, USA) contained a mixture of predominantly *I. hederacea* and *I. hederacea* var. *integriuscula*, but also included *I. lacunosa*. Crowley and Buchanan (1978) reported that the three species did not differ with respect to their effect on cotton yield. For this reason, no effort was made to select a single species for this research, and these three species are hereafter collectively referred as *Ipomoea* spp. At planting, *Ipomoea* spp. seedlings were 10- to 15-cm tall and at a 2-true-leaf stage. *Ipomoea* spp. seedlings were used to ensure that the intended *Ipomoea* spp. densities were achieved.

Transplanting occurred on May 21, 2020, at SWPAC and June 5, 2020, at MEIGS. Transplanting holes were punched in the polyethylene mulch with a manual hole punch at SWPAC and a water wheel transplanter at MEIGS. Four triploid watermelon seedlings were transplanted 1.2 m apart in each row, resulting in 12 triploid watermelon plants 27 m^{-2}. Two pollenizer watermelon seedlings were planted per row, which resulted in a 1:2 pollenizer-to-triploid watermelon ratio per plot. Immediately after watermelons were transplanted, *Ipomoea* spp. seedlings were planted into triploid watermelon transplanting holes to achieve densities of 0, 3, 6, 12, 18, and 24 *Ipomoea* spp. 27 m^{-2}. Only one *Ipomoea* spp. seedling was transplanted per hole for the densities of 3, 6, and 12 *Ipomoea* spp. 27 m^{-2}; one or two *Ipomoea* spp. seedlings per hole for the density of 18 *Ipomoea* spp. 27 m^{-2}; and two *Ipomoea* spp. seedlings per hole for the density of 24 *Ipomoea* spp. 27 m^{-2}. The 0 *Ipomoea* spp. 27 m^{-2} density was included as the weed-free control (Figure 1). The experimental design was a randomized complete block with four replications.

The lengths of the longest vines for all triploid watermelon and *Ipomoea* spp. plants in each plot were measured with a ruler from the soil surface in the planting hole to the vine growing point at 1, 2, and 4 WATr. After that, it was impractical to measure vine length, because the watermelon and *Ipomoea* spp. were intertwined. The *Ipomoea* spp. percent canopy cover was visually estimated at 6 and 8 WATr. Watermelon fruits were harvested once per week for 4 wk, beginning July 22 at SWPAC and August 19 at MEIGS. Fruits were picked when the tendril that developed from the same node as the fruit peduncle was necrotic and the ground spot was yellow. The weight of each fruit was recorded and classified as marketable (≥4 kg) or non-marketable (<4 kg). Total marketable yield and fruit number were calculated as the sum of marketable watermelon yield pooled across all four harvests.

At 1 wk after the last harvest, watermelon and *Ipomoea* spp. aboveground biomass was cut and collected using manual hedge shears from inside a 1-m^2 quadrat in the middle row of each plot. All biomass within a quadrat was placed inside a 114-L paper yard waste bag in the field to record total fresh weight. Watermelon and *Ipomoea* spp. biomass was separated in the laboratory. Watermelon biomass was oven-dried at 60 C for 24 h and the

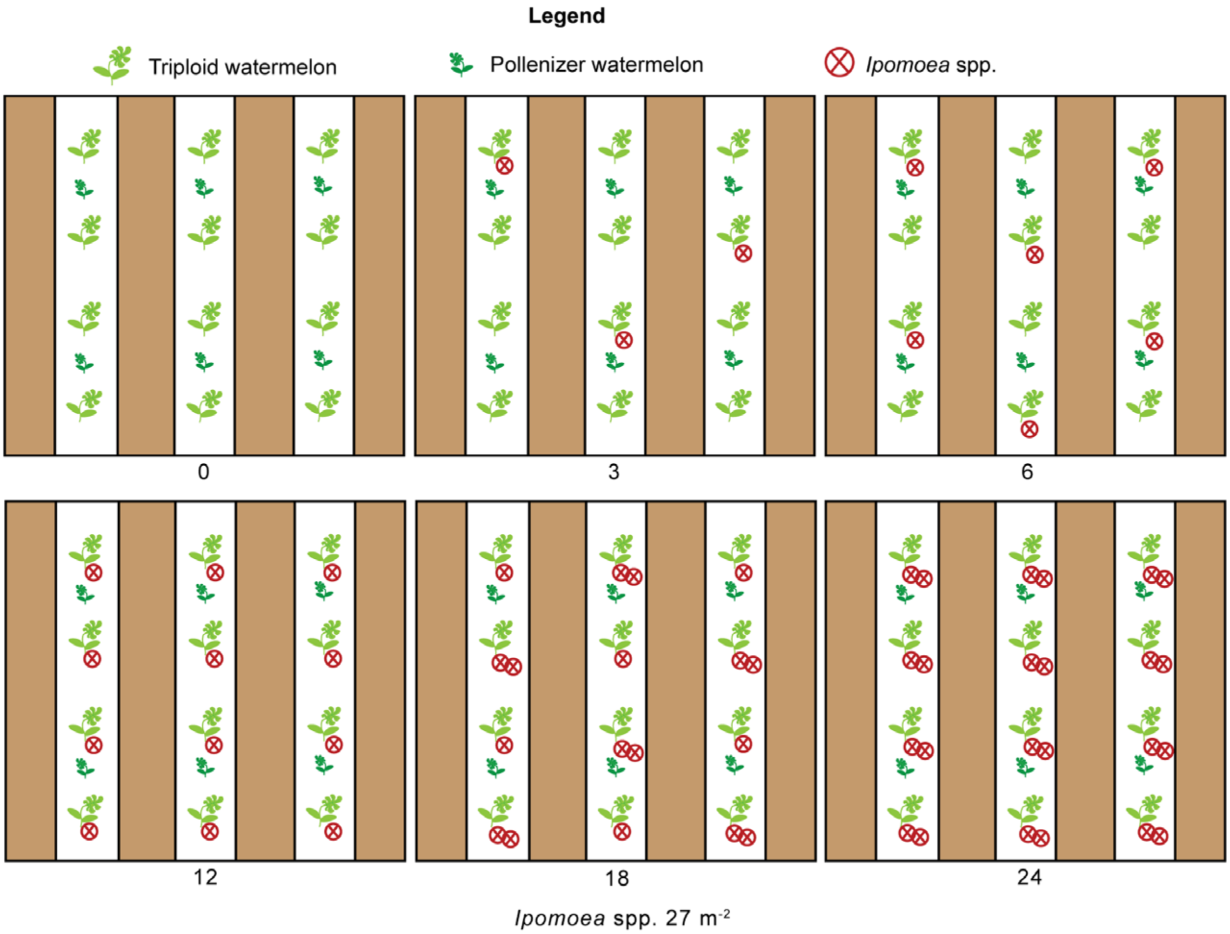

Figure 1. Additive design plot layout. Constant density of 12 'Fascination' triploid watermelon and six 'Wingman' pollenizer plants, and varied densities of 0, 3, 6, 12, 18, and 24 *Ipomoea* spp. 27 m^{-2}.

Ipomoea spp. biomass for 7 d to get aboveground dry biomass. After *Ipomoea* spp. dry weight was recorded, *Ipomoea* spp. seed capsules were separated and counted from the dried samples. Seed number from a subsample of 15 capsules was recorded and used to determine total seeds per square meter.

Marketable yield and fruit number, average individual fruit weight (including marketable and non-marketable fruits), and watermelon aboveground biomass were converted to a percent reduction of the weed-free control values using Equation 1:

$$\text{Percent reduction} = \frac{M - B}{M} \times 100 \qquad [1]$$

where M is the mean value of the weed-free control treatments average for each location and B is the variable value of each data point for each location.

R software (RStudio®, PBC, Boston, MA, USA) was used to analyze our data. Data were evaluated as a linear model and subjected to an ANOVA to determine whether statistically significant interactions ($P \leq 0.05$) existed between *Ipomoea* spp. density and location for each response variable. Response variables were watermelon vine length, *Ipomoea* spp. canopy cover percent at 6 and 8 WATr, marketable yield loss, marketable fruit number reduction, average individual fruit weight reduction, and watermelon aboveground biomass reduction.

R code from Oliveira et al. (2018b) was used to graph the results, using the *nls* (nonlinear least squares) function from the nlstools library to fit the rectangular hyperbola model (Cousens 1985) and Equation 2:

$$\text{Yield loss} = \frac{I * x}{1 + \left(\frac{I}{A}\right) * x} \qquad [2]$$

where x represents *Ipomoea* spp. density in plants 27 m^{-2}, I represents yield loss per unit weed density as x approaches zero, and A represents yield loss as x approaches infinity.

Data from the weed-free control were excluded from the seed production ANOVA due to zero variance. Seed production without the weed-free control data were then subjected Tukey's Honest Significant Difference (HSD) test to separate mean seed production at a $P \leq 0.05$ significance level if density was statistically significant.

Results and Discussion

Watermelon Vine Length and Ipomoea spp. Canopy Cover

Watermelon vine length was not affected by the presence of *Ipomoea* spp. at 1, 2, or 4 WATr at either location (data not shown). However, by 6 and 8 WATr, percent *Ipomoea* spp. canopy cover was affected by *Ipomoea* spp. density. *Ipomoea* spp. canopy cover

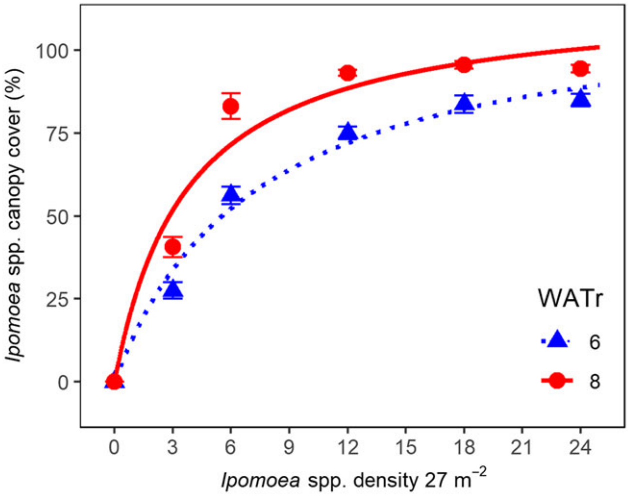

Figure 2. Relationship between *Ipomoea* spp. density and *Ipomoea* spp. canopy cover percent at 6 and 8 wk after transplanting (WATr) described with a rectangular hyperbola. The model is $y = (I*x) \div [1 + (I * x/A)]$, where $I = 15.97$ and $A = 115.33$ at 6 WATr, and $I = 31.29$ and $A = 115.86$ at 8 WATr. Data points represent the observed mean data with their SE bars, and the solid and dashed lines represent the predicted values based on the model for each WATr. Data were pooled across two locations in 2020: the Southwest Purdue Agricultural Center (SWPAC) and Meigs Horticulture Farm (MEIGS), Indiana, USA.

data were combined across locations due to a nonsignificant treatment-by-location interaction. As the density of *Ipomoea* spp. increased from 3 to 24 plants 27 m^{-2}, predicted *Ipomoea* spp. percent canopy cover increased from 34% to 89% at 6 WATr and 52% to 100% at 8 WATr (Figures 2 and 3).

Harvest Interference

The presence of *Ipomoea* spp. hindered the harvest process by hiding watermelon fruits and wrapping around the fruit (Figure 4). Although harvesting efficiency was not measured, it is most likely that *Ipomoea* spp. slowed the harvesting, because multiple *Ipomoea* spp. vines had to be removed or cut to harvest the fruits. The impact of *Ipomoea* spp. interference on harvesting efficiency is well documented in other crops.

Schutte (2017) reported that the presence of *I. purpurea* slowed the manual harvesting of chile pepper (*Capsicum annuum* L.). He also stated that professional chile pepper harvesters typically would avoid weedy areas, but if they did harvest weedy patches, it would extend harvesting time. Wood et al. (1999) judged it impossible to mechanically harvest cotton without damaging the equipment at some locations at *I. hederacea* densities of 10 and 12 weeds 10 m^{-1}. Ellis et al. (1998) reported that the combine speed to harvest soybean was slowed slightly with *I. hederacea* densities of 0.25, 0.5, 1, and 2 plants row m^{-1}. Wilson and Cole (1966) reported that the presence of *I. hederacea* and *I. purpurea* caused severe soybean lodging and decreased harvest availability. Conducting a trial to determine watermelon manual harvest efficiency in the presence of various weeds could be beneficial to corroborate our results.

Marketable Watermelon Yield and Fruit Number

Marketable yield loss and fruit number reduction data were combined across locations due to a nonsignificant treatment-by-location interaction. Marketable yield and fruit number of the weed-free control were 187 kg and 26.3 fruits 27 m^{-2}. As *Ipomoea* spp. density increased from 3 to 24 plants 27 m^{-2}, predicted marketable watermelon yield loss increased from 58% to 99% (Figure 5) and predicted marketable fruit number reduction increased from 49% to 98% (Figure 6). These models followed almost an identical path as that of the model for the canopy cover percent at 8 WATr (Figure 2), suggesting that *Ipomoea* spp. canopy cover at 8 WATr is an indicator of yield loss.

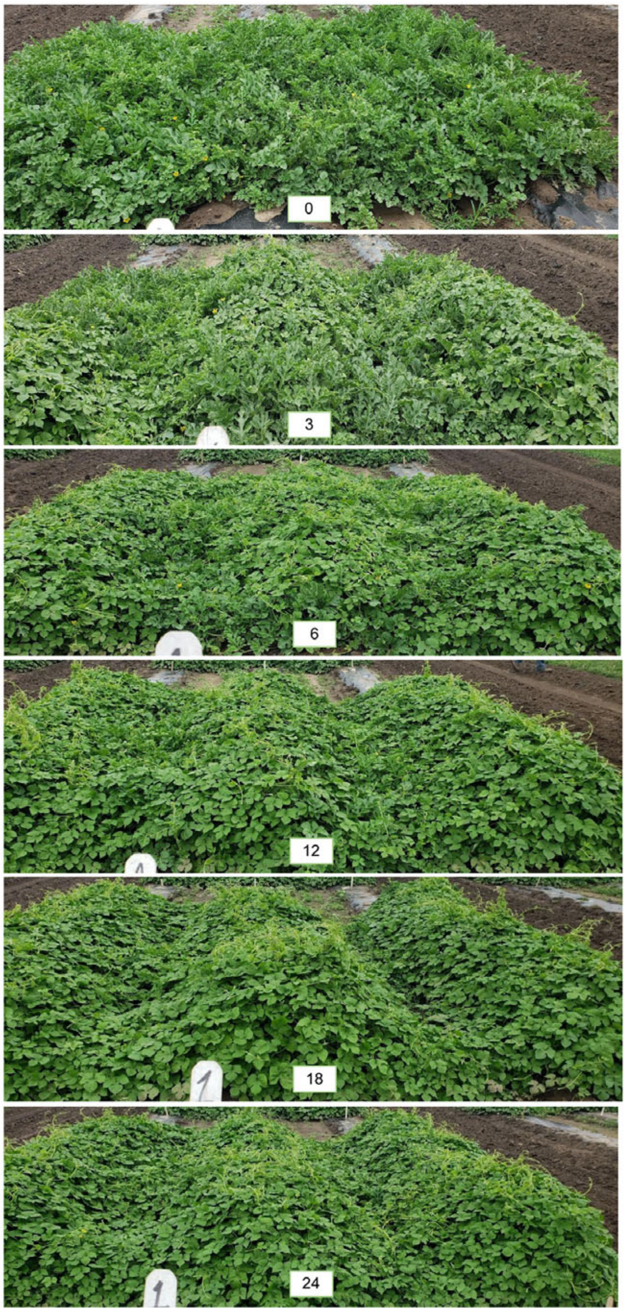

Figure 3. Plot canopy cover at densities of 0, 3, 6, 12, 18, and 24 *Ipomoea* spp. 27 m^{-2} at 8 wk after transplanting (WATr) at the Southwest Purdue Agricultural Center (SWPAC), Indiana, USA, in 2020.

Average Individual Fruit Weight

Individual fruit weight reduction data were combined across locations due to a nonsignificant treatment-by-location interaction.

Figure 4. *Ipomoea* spp. vines wrapped around a watermelon fruit at harvest at Meigs Horticulture Research Farm (MEIGS), Indiana, USA, in 2020.

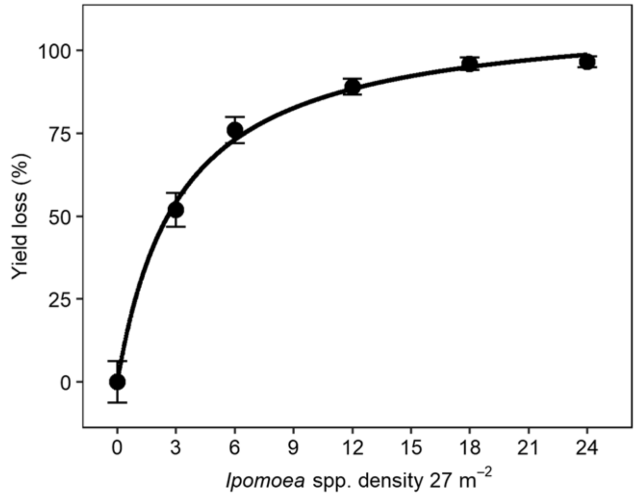

Figure 5. Relationship between *Ipomoea* spp. density and watermelon marketable yield loss described with a rectangular hyperbola. The model is $y = (I * x) \div [1 + (I * x/A)]$, where $I = 40.80$ and $A = 109.89$. Data points represent the observed mean data with their SE bars, and the solid line represents the predicted values based on the model. Fruit was classified as marketable if ≥4 kg. Data were pooled across two locations in 2020: the Southwest Purdue Agricultural Center (SWPAC) and Meigs Horticulture Farm (MEIGS), Indiana, USA.

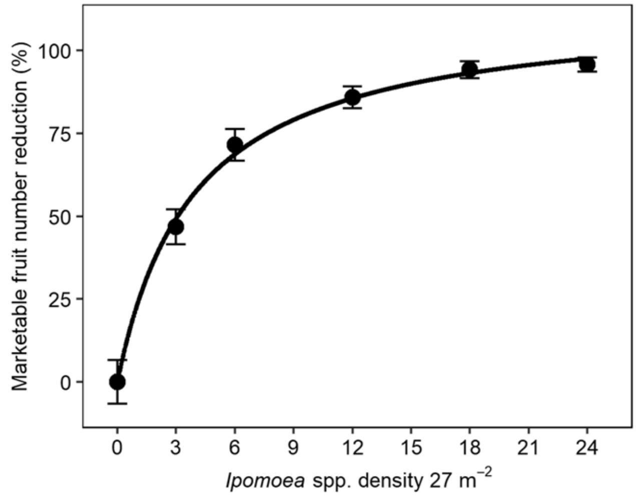

Figure 6. Relationship between *Ipomoea* spp. density and watermelon marketable fruit number reduction described with a rectangular hyperbola. The model is $y = (I * x) \div [1 + (I * x/A)]$, where $I = 29.16$ and $A = 113.29$. Data points represent the observed mean data with their SE bars, and the solid line represents the predicted values based on the model. Fruit was classified as marketable if ≥4 kg. Data were pooled across two locations in 2020: the Southwest Purdue Agricultural Center (SWPAC) and Meigs Horticulture Farm (MEIGS), Indiana, USA.

The mean fruit weight of the weed-free control was 7.4 kg per fruit. As *Ipomoea* spp. density increased from 3 to 24 plants 27 m^{-2}, predicted individual fruit weight reduction increased from 17% to 45% (Figure 7).

This study confirmed that watermelon is a poor competitor with weeds, and these results are consistent with the severe watermelon yield loss caused by other weeds. Season-long American black nightshade (*Solanum americanum* Mill.), at a density of 2 plants m^{-2}, reduced watermelon yield 54% to 58% (Adkins et al. 2010; Gilbert et al. 2008). A 10% watermelon yield loss was observed with only 2 yellow nutsedge (*Cyperus esculentus* L.) plants m^{-2} permitted to grow season-long (Buker et al. 2003). Season-long interference of 6 smooth pigweed (*Amaranthus hybridus* L.) plants m^{-1} reduced watermelon yield approximately 60% (Terry et al.1997), and 1 Palmer amaranth (*Amaranthus palmeri* S. Watson) per planting hole reduced the yield of three watermelon varieties from 45% to 75% (Bertucci et al. 2019a).

Adkins et al. (2010), Buker et al. (2003), and Gilbert et al. (2008) reported yield loss due to fruit number reduction but not smaller fruit size. However, Terry et al. (1997) reported a 37% reduction in individual watermelon fruit weight at a density of 6 *A. hybridus* m^{-1}, and Bertucci et al. (2019a) reported a 9% reduction in individual fruit weight at 4 *A. palmeri* per planting hole. In the current study, individual fruit weight reduction impacted yield loss.

Watermelon Aboveground Biomass

Watermelon aboveground biomass reduction data were combined across locations due to a nonsignificant treatment-by-location interaction. Mean watermelon aboveground biomass dry weight

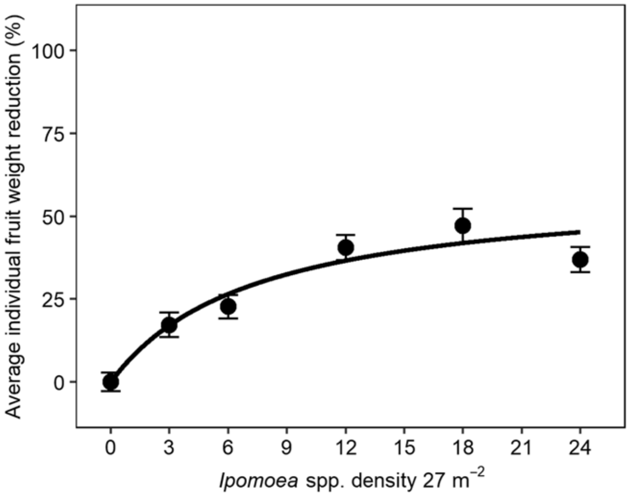

Figure 7. Relationship between *Ipomoea* spp. density and watermelon average individual fruit weight reduction (marketable and non-marketable fruits) described with a rectangular hyperbola. The model is $y = (I * x) \div [1 + (I * x/A)]$, where $I = 8.05$ and $A = 58.97$. Data points represent the observed mean data with their SE bars, and the solid line represents the predicted values based on the model. Fruit was classified as marketable if ≥4 kg and non-marketable if <4 kg. Data were pooled across two locations in 2020: the Southwest Purdue Agricultural Center (SWPAC) and Meigs Horticulture Farm (MEIGS), Indiana, USA.

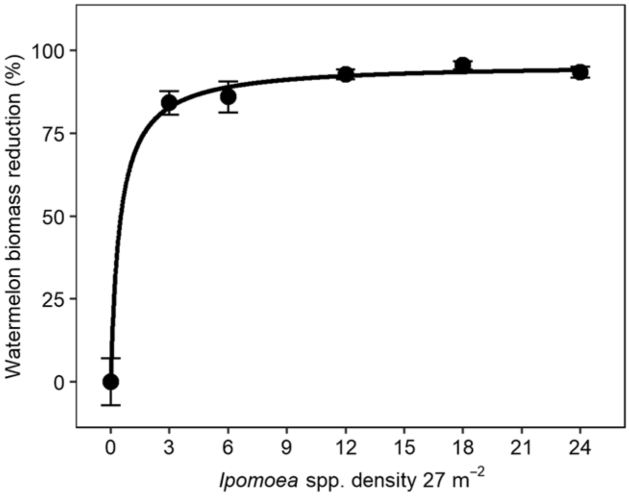

Figure 8. Relationship between *Ipomoea* spp. density and watermelon biomass reduction in 1 m^2 described with a rectangular hyperbola. The model is $y = (I * x) \div [1 + (I * x/A)]$, where $I = 202.96$ and $A = 95.94$. Data points represent the observed mean data with their SE bars, and the solid line represents the predicted values based on the model. Watermelon biomass data were collected from a 1-m^2 plot and oven-dried at 60 C to obtain dry weight. Data were pooled across two locations in 2020: the Southwest Purdue Agricultural Center (SWPAC) and Meigs Horticulture Farm (MEIGS), Indiana, USA.

of the weed-free control was 292 g m^{-2}. Predicted watermelon biomass reduction increased from 83% to 94% as the *Ipomoea* spp. density increased from 3 to 24 plants 27 m^{-2} (Figure 8).

Watermelon biomass reduction has not been reported in the studies mentioned previously, but in this study, *Ipomoea* spp. significantly affected watermelon aboveground dry biomass. Dry matter partitioning into the harvestable organs contributes to the crop's yield, and leaves are the primary source of dry matter. In vegetable crops in which harvest is performed over an extended period, a balance between dry matter partitioning into the fruits and other vegetative organs is essential (Marcelis et al. 1998). Because *Ipomoea* spp. outgrew and covered the watermelon plants, watermelon plants could not photosynthesize at a rate high enough to create dry matter. Consequently, biomass reduction most likely is the primary reason for yield loss and the reduction in fruit number and fruit weight reduction in the presence of season-long *Ipomoea* spp.

Table 1. *Ipomoea* spp. seed production (±SE) at the Southwest Purdue Agricultural Center (SWPAC) and Meigs Horticulture Farm (MEIGS), Indiana, USA, in 2020.

Density	*Ipomoea* spp. seed production[a]	
	SWPAC[b]	MEIGS
Ipomoea spp. 27 m^{-2}	seeds m^{-2}	
3	1,956 (205) a	6,659 (2,617)
6	1,432 (404) ab	7,213 (2,067)
12	1,045 (303) ab	5,016 (1,081)
18	549 (62) b	6,880 (748)
24	555 (200) b	7,746 (1,302)

[a] Seed production (seeds m^{-2}) was obtained by counting the total seed capsules in 1 m^2, counting the number of seeds in 15 capsules, and then extrapolating the total number of seeds in that 1 m^2.

[b] Means separation applying Tukey's HSD at a $P \leq 0.05$ significance level. Means that do not share a common letter are significantly different.

Ipomoea spp. Seed Production

Ipomoea spp. seed production data were analyzed by location. Pooled across all *Ipomoea* spp. densities, seed production was greater at MEIGS (6,703 seeds m^{-2}) than at SWPAC (1,007 seeds m^{-2}) (data not shown). *Ipomoea* spp. density was significant at SWPAC but not at MEIGS. *Ipomoea* spp. seed production ranged from 549 to 1,956 seeds m^{-2} at SWPAC and from 5,016 to 7,746 seeds m^{-2} at MEIGS (Table 1). Unexpectedly, at SWPAC, the lowest density of 3 *Ipomoea* spp. 27 m^{-2} had a significantly higher seed production (1,956 seeds m^{-2}) than the two highest densities of 18 and 24 *Ipomoea* spp. 27 m^{-2} (549 and 555 seeds m^{-2}, respectively).

Seed production at MEIGS is comparable to the values reported by Crowley and Buchanan (1982) and Gomes et al. (1978): 5,000 and 14,600 seeds per one *I. hederacea* var. *integriuscula*, 10,000 and 15,200 seed per one *I. lacunosa*, and 6,000 and 5,800 seed per one *I. hederacea*, respectively. However, seed production may have been affected by intraspecific competition at both locations, but SWPAC was more affected than MEIGS. Colom and Baucom (2020) reported that intraspecific competition of two *I. hederacea* reduced seed production by approximately 35% with respect to a single *I. hederacea*. Another possible reason for reduced seed production at SWPAC compared with MEIGS would be the effect of environmental factors not measured.

Overall, this study demonstrated that watermelon production is significantly affected by the presence of *Ipomoea* spp. that are permitted to grow season-long. If *Ipomoea* spp. escape initial weed control practices and grow all season, they will hinder harvest and reduce yield, fruit number and size, and biomass because of their propensity for climbing, vining, and twining. *Ipomoea* spp. densities increasing from 3 to 24 plants 27 m^{-2} increased watermelon yield loss from 58% to 99%, watermelon fruit number reduction from 49% to 98%, watermelon fruit weight reduction from 17% to 45%, and watermelon aboveground biomass reduction from 83% to 94%.

Despite no *Ipomoea* spp. density affecting watermelon vine length at early stages, by 6 and 8 WATr, *Ipomoea* spp. outgrew the watermelon, and the canopy cover of *Ipomoea* spp. was prominent as the *Ipomoea* spp. density increased. The most likely reason for watermelon yield loss in this study was due to interference with light and consequently less dry matter being partitioned into fruit development due to less photosynthesis. This study also demonstrated that *Ipomoea* spp. seed production increases the weed seedbank in the soil immensely, reinforcing the importance of postharvest weed control.

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