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Potential Impacts of Methyl Jasmonate for Disease Control in Hoophouse vs. Field, and Increased Flower Life Post-Harvest for Cut Flowers: Sunflowers and Zinnias

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Fresh cut flowers in vase or bouquet add cheer and joyfulness to the consumer and can be a profitable enterprise for growers. This trial was conducted during the seasons of 2018 and 2019 at two locations in Wisconsin: West Madison ARS (WMARS) in southern WI and Rhinelander ARS (RARS) in northern WI. This trial included two species of cut flowers: Sunflower and Zinnias. Two aspects of research were addressed: 1) Evaluation of incidence of powdery mildew on sunflowers and bacterial leaf spot disease on zinnias grown under a hoophouse vs. field environments; and 2) Evaluation of the potential effectiveness of plant chemical treatments on sunflowers and zinnias foliage diseases.

Hoophouses are simple hooped structures with plastic on the top and sides to extend the growing season and to protect plants from harsh weather (strong wind, hail, driving rain). They can, however, overheat during high temperatures so precautions are necessary to reduce the excess heat by opening the sides and ends to increase air flow, and to keep plants thoroughly watered. During winter months, heavy snow loads on top of the hoophouse can cause it to cave in and be destroyed. More overhead and management are linked to these structures so for our first objective, we wanted to evaluate if the return on investment is achieved by having healthier and more productive, abundant marketable products than without a hoophouse. To address our second objective, methyl jasmonate was chosen as a comparison to previously tested chemical 'Regalia', an organically approved product which we had tested on cut flowers in the past. In addition to plant disease assessment, plant heights, total marketable blooms, insect incidence and vase life were compared across environments and chemical treatments.

MATERIALS & METHODS

Experimental Design

Each 10' x 20' hoophouse was planted half to sunflowers and half to zinnia. Investment costs for the plastic, framing materials, and micro-irrigation were prorated over a 10-yr life at $25/yr. To calculate return on hoophouse investment, we used $5/bouquet of eight blooms per zinnia bouquet and three blooms per sunflower bouquet. The zinnia variety for both years and both locations was 'Oklahoma Mix'. The sunflower variety in 2018 at both locations was 'Music Box Mix' and was changed in 2019 to 'Soraya' because it was pollenless, more uniform, and had a longer lifespan. All varieties were continuous blooming types. The zinnias were somewhat petite with 1.5-2" blooms and the sunflower blooms were medium sized, 3- 4" in diameter. Locations were analyzed and reported separately due to experimental design differences and resource constraints.

WMARS

The experimental design was a randomized block with three replicates each of hoophouse and field environments. Within each environment, a 100 sq ft area was planted with 32 sunflowers and the other 100 sq ft planted with 32 zinnia plants. Plots had two plants each with plant spacing set at 2.5 ft by 2.5 ft. For each flower specie in each environment, four replicate plots were treated with Regalia, four other plots were treated with methyl jasmonate, and four other plots were the untreated check. P-values (i.e. the probability that the effect was due to chance) are reported to show statistically significant differences.

RARS
Only one hoophouse environment and one field plot were used for both flower specie each season so 'year' was used as the replicate factor to test statistical differences on environment when possible; standard errors around each mean are reported, as well. Within each environment, 32 sunflowers and 32 zinnias were evaluated in five replicate plots (2 ft by 3 ft) of two plants each that were treated with A) Regalia, B) methyl jasmonate, and C) untreated check.

Hoophouse Vs. Field Environment
WMARS
After establishing plants in a greenhouse for 15 days, the 2-week old plants (~8" height) were transplanted in the ground under the hoophouse in mid-May to June 1 over the two years. Dripline was installed for metering water to the plants once a week. Field plots were planted two weeks later (or when the threat of a late Spring frost had past) than hoophouse and were rainfed or irrigated with overhead sprinklers as needed. Leaf mulch was applied to both environments to control weeds and conserve moisture.

RARS
Two-week old greenhouse plants were transplanted into containers in the hoophouse between May 22 and June 1 over the two years and watered at the soil surface. Field plots were planted two to three weeks later and mulched with hay. Heavy rainfall in 2018 on June 15th and again on June 17th led to root borne disease that severely affected the field zinnia plots. Field sunflowers were affected to a lesser extent due to the cold, wet soils. Still, as a proxy, healthy border zinnias and sunflowers were planted in 2018 at the same time to compare relative heights, health, and bloom counts vs. those plants in the hoophouse. In 2019, hoophouse sunflower plants had to be re-established as most died from 100°F temperatures inside the hoophouse in early June (though zinnias tolerated the heat better and survived). New sunflower plants were seeded in late May and transplanted June 12, the same day as the field treatment.

Plant Chemical Treatments
Two plant-based chemicals, 'Regalia' and methyl jasmonate (Table 1), as well as, an untreated control plot were compared over these two years at the two locations in both the hoophouse and field environments. 'Regalia', a certified organic bio-fungicide, induces a response in the plant's defense systems by producing cell strengtheners, antioxidants, phenolics, and pathogenesis-related proteins which inhibit plant pathogens (both fungal and bacterial) internally. Methyl jasmonate, a plant growth regulator, activates plant defense mechanisms in response to biotic and abiotic stress by inducing systemic or local protection. However, methyl jasmonate has been shown to shorten plant stems and increase post-harvest floral abscission. At each location, chemical treatments were initiated in late June through late September and applied on a biweekly schedule. Each product was directly applied to the plant foliage using a hand-held sprayer.

Table 1. Characteristics of plant chemicals used in the trials.			
Common name	**Active ingredient**	**FRAC Code or Mode of Action***	**Recipe**
Methyl jasmonate	7-iso Jasmonic acid	PGR, activates plant defense mechanisms	200 microliters of methyl jasmonate, with 980 ml distilled water, and 20 ml ethanol
Regalia	Extract of giant knotweed (*Reynoutria sachalinensis)*	Induces Systemic Resistance (P5)	1 oz of Regalia/gal of water, + sticker

* FRAC=Fungicide Resistance Action Committee, FRAC Code list 2013

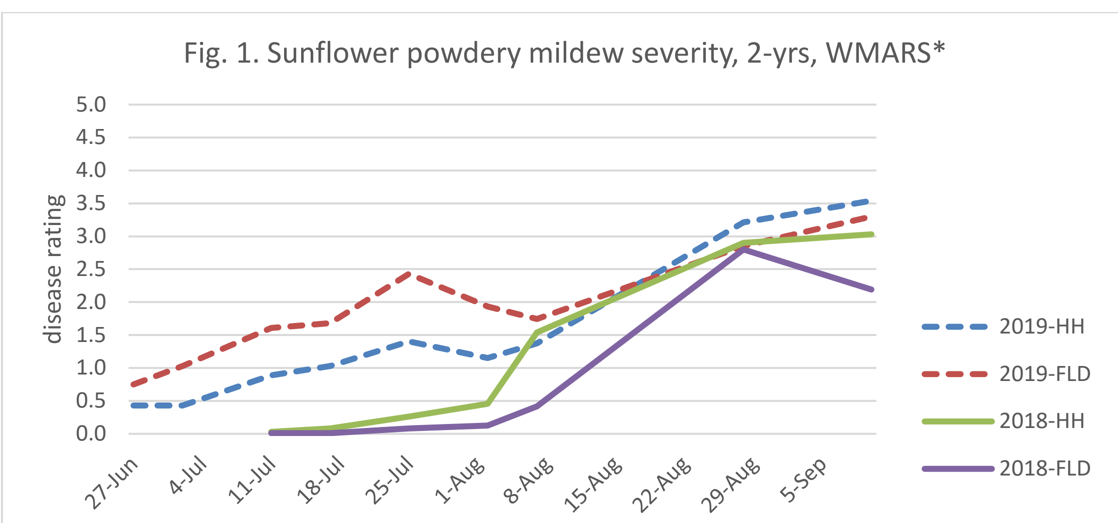
Variables Measured

Disease and insect severity ratings were taken weekly over the summer using a scale of 1 to 5 with 1 having virtually no evidence of damage and 5 having full-blown, fatal severity. Plant heights were measured weekly. Blooms were harvested biweekly and marketable stems were totaled for the season. Three vase life periods were monitored: July, August, and September. Some data are summarized across site-yrs which is the combination of location and year (i.e. WMARS-2018, WMARS-2019, RARS-2018, RARS-2019 individually equal a site-yr, collectively four site-yrs).

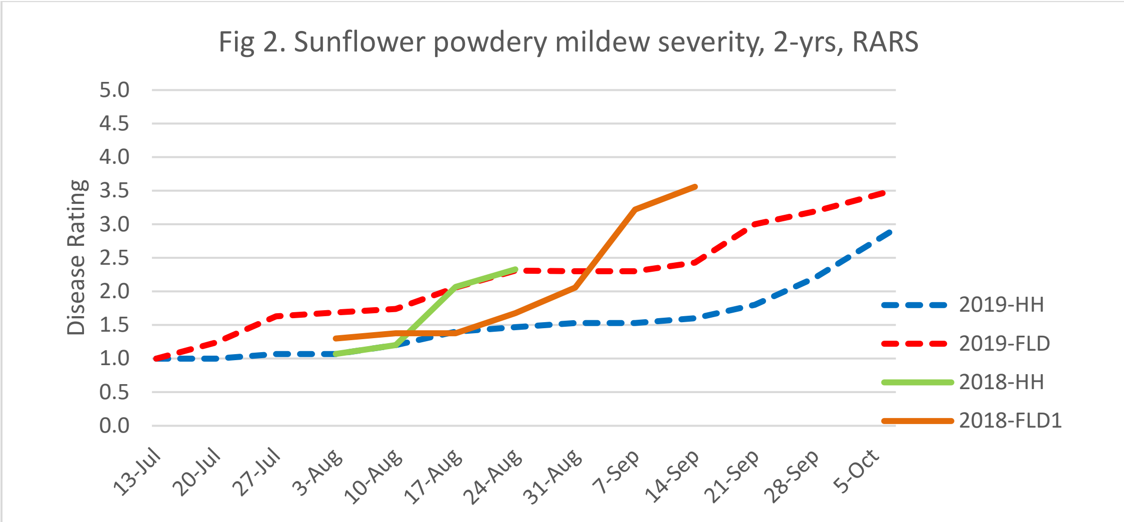
RESULTS

<u>Disease</u>

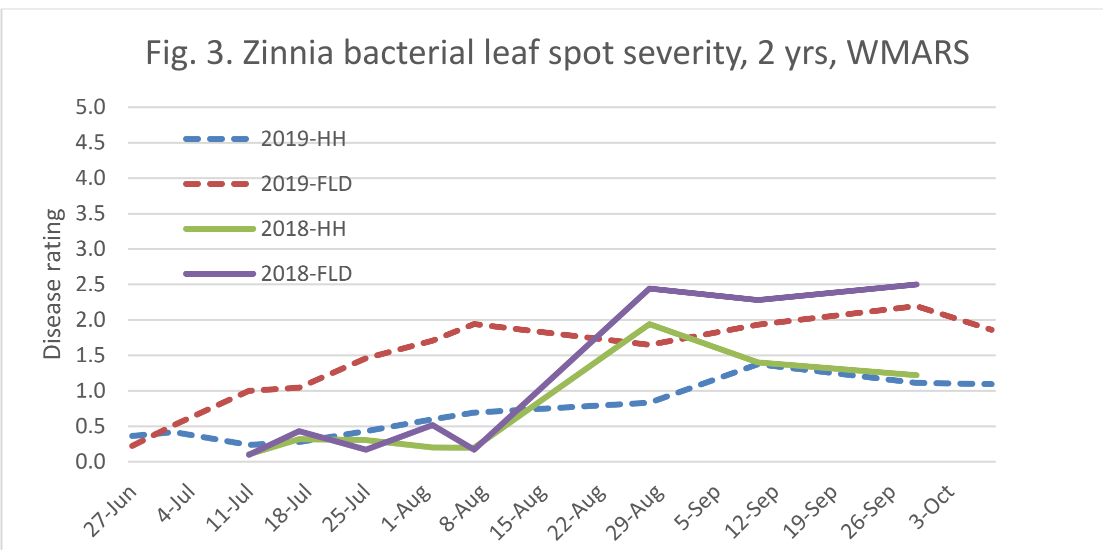
Sunflowers are naturally short-lived lasting about three months while zinnias last all season until a killing frost. The two flower species were susceptible to different diseases and there were different responses to the environments. Sunflower was primarily afflicted with powdery mildew (PM) from late July to early September. Powdery mildew flourishes at temps between 70 and 80°F and high air humidity and out of direct sunlight (conditions common under hoophouses in summer). The sunflower disease incidence at WMARS was varied by year: It was statistically higher in the hoophouse vs. field in 2018 while the field environment showed more PM than hoophouse in 2019 (Fig. 1). However, hoophouse environment at RARS had lower PM severity on sunflowers because they used fans to help with cooling and ventilation (Fig. 2 and Table 2). There was no effect of chemical treatment nor a chemical x environment interaction in any week of either year on sunflowers at either location.



(*Environment at each date within a given year was significantly different at $p<0.05$ or less)



Zinnias were susceptible to bacterial leaf spot and it was detected at the locations in late July onward (Fig. 3, 4). The field plants had significantly higher leaf spot disease than the hoophouse plants at all four site-yrs (Fig. 3, 4, Table 2) though severity was relatively low in most cases. Essentially there was no impact for disease control with the two chemical treatments at either location in either hoophouse or field environments. Overall, the plant chemical treatments weren't worth the time or expense on these varieties tested.



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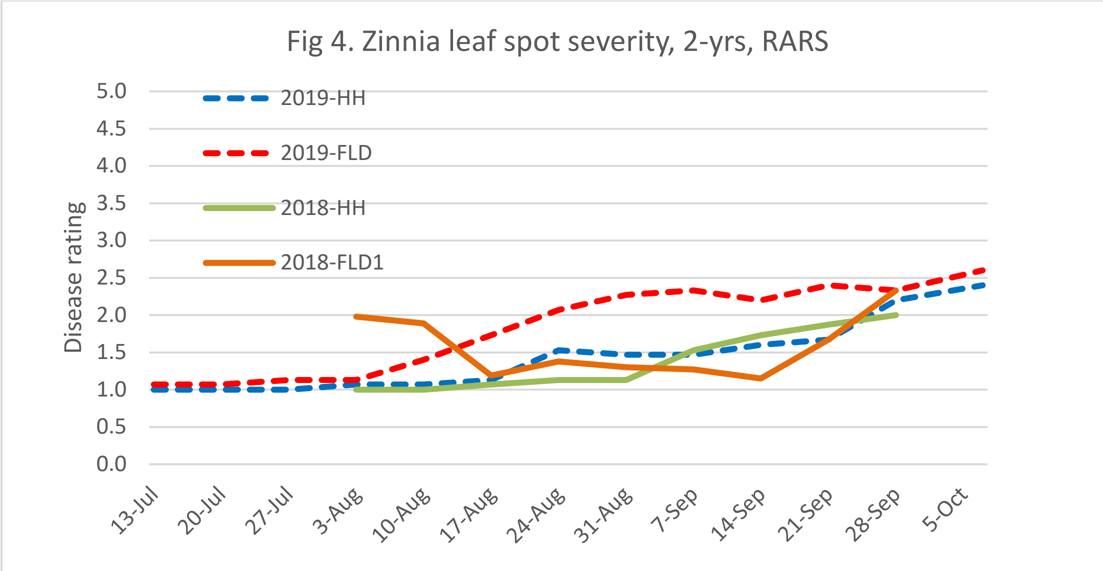

Table 2. Overall disease ratings (1=no disease, 5=full blown disease) at RARS on sunflower and zinnia, 2-season average.			
	Environment	Disease	SEM*
Sunflower	Hoophouse	1.52	0.045
	Field	2.02	0.058
		p<0.0001	
Zinnia	Hoophouse	1.38	0.033
	Field	1.71	0.049
		p<0.0001	
*SEM = standard error of the mean			

Insects –WMARS only

Pollinators were highly attracted to both zinnias and sunflower plants but no major differences among environment or treatments were found. No pest differences were found on sunflowers grown under hoophouse vs. field or among the chemical treatments. Japanese beetles were the primary insect pest on zinnias and pest pressure in the field environment was statistically higher each week than the hoophouse ($p<0.01$ or lower) but no chemical treatment differences were detected.

Plant Heights

Overall average heights of sunflowers are shown in Table 3 and there was no big difference in overall heights between environments at the two locations. In 3 of the 4 site-yrs, the hoophouse plants were taller earlier in the season vs. field, but they were shorter in the latter half of the season than the field environment (data not shown). It's possible the plastic hoophouse roof (6 mil thickness) screened out some light wavelength that didn't allow the sunflowers to keep growing in late summer as the field plants did. Field grown plants seemed to branch more but hoophouse sunflowers still had a slight advantage over field-grown sunflowers in total blooms produced (Table 5). No significant effect on height from the chemical treatment was found at either location.

Table 3. Average height per plant of sunflowers in 2018 ('Music Box Mix') and 2019 ('Soraya') at two locations.					
Location	Environment	2018 Height (inches)	2018 SEM**	2019 Height (inches)	2019 SEM
WMARS	Hoophouse	28.8	0.689	44.6	0.528
	Field	29.0	0.578	41.6	0.479
		NS*		p<0.05	
RARS	Hoophouse	31.3	0.444	44.6	1.01
	Field	32.3	0.719	43.0	1.39
*NS=not significantly different; ** SEM=standard error of the mean					

Trends across locations were similar for zinnia plant heights. Hoophouse zinnia plants were consistently much taller throughout the season than the field grown zinnias (data not shown) and when averaged across both years and over the season, hoophouse zinnias were statistically taller than the field grown plants (Table 4).

Table 4. Average height per plant of zinnias averaged over 2018 and 2019.			
Location	Environment	Height (inches)	SEM*
WMARS	Hoophouse	34.0	0.465
	Field	25.8	0.281
		p<0.0001	
RARS	Hoophouse	35.3	0.473
	Field	17.3	0.459
		p<0.0001	
*SEM=standard error of the mean			

Total blooms for sunflower and zinnia were higher under the hoophouse environment at WMARS though it was variable by year at RARS (Table 5). Hoophouse plants had higher market value because more marketable stems per plant were harvested due to a longer growing season and less diseased, damaged foliage from that environment produced healthier blooms.

Table 5. Total blooms per plant of sunflower and zinnia at two locations and 2 years.						
	Sunflower			Zinnia		
	HH	Field	Difference between Envs	HH	Field	Difference between Envs
WMARS-2018	78	68	+10*	163	151	+12
WMARS-2019	28	22	+6*	No data	No data	
RARS 2-yr avg.	33	32	NS	120	82	+38*
*significantly different at p<0.05; NS=not significantly different						

Marketable Blooms.

Overall, the field-grown flowers were more battered from the heavy rain, strong winds, and hail events vs. the hoophouse plants at both locations. For example, in 2018 at RARS, the field plants suffered from root born disease from wet, cold soils just after transplanting, and at WMARS by

September, field zinnia plants had only about ¼ of their original foliage left to support blooms vs. ¾ of healthy plant foliage in hoophouse. Many field plants were lodged with broken branches from the conditions along with more damaged foliage reduced bloom quality. As a result, many more marketable blooms were produced under the hoophouse. On average (across 2 species and 4 site-yrs) the hoophouse system netted $346 more per 32 plants (or $10.81/plant) at $5/bouquet than the field environment in bloom income.

Table 6. Profit Margin in hoophouse (HH) vs. field (8 blooms/zinnia bouquet; 3 blooms/sunflower bouquet at $5/bouquet) across 2 yrs

	Extra blooms/plant in HH	Extra bouquets /plant in HH	Gross across 32 plants in HH x $5/bouquet	Net after $25/yr HH expense
Sunflower, WM	+8	+2.7	+$432	+$407
Sunflower, R	+1	+0.3	+$53	+$28
Zinnia, WM	+12	+1.5	+$240	+$215
Zinnia, R	+38	+4.75	+$760	+$735
	Overall average profit for Hoophouse:			**$346/32 plants Or $10.81/plant**

Vase Life

Vase life for both species was higher for the hoophouse environment in August and September test periods (no difference in July) by a week (for sunflowers) to 10 days (for zinnias). The blooms were brighter and less weathered under the hoophouse conditions. No differences were detected among the chemical treatments in either environment or location.

CONCLUSION

Hoophouse plants had improved floral quality and longer vase life than field grown plants by being protected under the plastic. Hoophouses also extended the season by up to a month (2 weeks in Spring and 2 weeks in the Fall after a killing frost). Variety choice is important when growing cut flowers as some are single bloom while others are continuous blooming and size and duration of blooms, and pollen shed differ by variety. Given the longer season of producing cleaner flowers, the hoophouse was more profitable than the field grown system. However, hoophouses do add to the management during the year that needs to be realized.

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