EFFECT OF PLANT POPULATION DENSITY AND PESTICIDE APPLICATION TECHNOLOGY ON INSECT PESTS AND DISEASES OF BELL PEPPERS IN OHIO

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Introduction

Plant population density and pesticide application technology can influence the management of insect pests and diseases as well as fruit yield of bell pepper [*Capsicum annuum*]. Many studies have investigated the impact of pepper stand density on yield (Gaye et al., 1992; Locascio and Stall, 1994; Jolliffe and Gaye, 1995), but little information exists about its implications on pesticide efficacy. Although greater pepper fruit yields are usually reported at higher plant stand densities, denser crop canopies have the potential to diminish the amounts of spray deposits reaching the surface of fruit in the lower canopy. The biological significance of pesticide application techniques on pests and yield has been reported for other crops (Welty et al., 1995; Derksen et al., 2001), but not on peppers. The objective of this study was to determine the effect of plant population density and pesticide application techniques on fruit yield and on the control of key insect pests and diseases of peppers.

Materials and Methods

2004. A randomized complete block design was employed with 9 treatments and 4 replicates. Treatments were

SPRAYER	NOZZLE	RATE	SPEED
1. Conventional boom	AI11005	half	8 mph
2. Conventional boom	AI11025	half	4 mph
3. Conventional boom	AI11025	full	4 mph
4. Conventional boom	TJ60-11003	half	4 mph
5. Conventional boom	TJ60-11006	half	8 mph
6. Air-assist boom	XR11003	half	8 mph
7. Air-assist boom	XR110015	half	4 mph
8. Electrostatic/air-assist boom	Maxcharge™	half	4 mph

9. Untreated check.

The air-assist boom was a Myers Mity Mist sprayer (Ashland, OH), the conventional boom was a Cagle sprayer (Cagle Mfg. Co., Inc., a division of Hardee Williams, Inc., Coconut Creek, FL), and the electrostatic/air-assist boom was a ESS sprayer (Electrostatic Spraying Systems, Inc., Watkinsville,GA). Plots consisted of 60 ft long twin rows of pepper cv. 'Socrates' plants and an untreated twin-row guard on each side with replications separated by 30 ft alleys. Eight pesticide applications were made between 28 July and 19 Sep.

2005. The study was arranged in a 2 x 3 x 3 factorial design with two row arrangements (twin and single rows), three plant population densities (low, medium, and high, corresponding to 11, 15, and 22 inches within-row spacing in single rows and to 15, 20, 30 inches within-row spacing in twin rows, respectively), and three types of pesticide application technology (TJ60-11003, AI1110025 nozzles, and an untreated check) with four replicates of each combination of treatments. Seven pesticide applications were made between 25 July and 6 Sep.

The harvested area was 10 ft of twin rows and 5 ft of single rows from the center of each plot. All fruit were inspected for external damage, then cut open to determine presence of larvae or damage. In 2005, all trials had to be terminated early due to heavy damage by *Phytophthora capsici*. Therefore, in the final harvest, bell pepper green fruit with a diameter larger than 2.5 inches were evaluated in addition to red fruit.

Results

2004. In general, the air-assisted electrostatic sprayer resulted in fruit yields that were lower than those obtained in the conventional boom sprayer treatments (Table 1). The air-assisted sprayer had the lowest quantities of spray deposits on leaves at the top of the canopy, and TwinJet flat-fan nozzles left the greatest spray deposition on leaves at the bottom of the plant canopy (Figure 1). The conventional boom sprayer (provided with TwinJet or air induction nozzles) resulted in more spray deposits on the top canopy than the air-assisted sprayer in both years, but there were no significant differences in spray deposits at the bottom plant canopy in either year (Figure 2).

2005. Greater yield was obtained from single row than from twin row treatments. However, twin rows had less insect damage than single rows. Low stand density resulted in lower estimated clean yield than middle or high stand density. TJ60-11003 nozzle had greater yield than AI110025 nozzle; and AI110025 had greater yield than the untreated check. As expected, insect damage was greater in the untreated check than in plots that received insecticide applications, but there were no significant differences among the treated plots (Table 2). Pest pressure was lower than normal in 2005.

Table 1. Effect of pesticide application technology on yield, percentage of European corn borer-damaged fruit, fruit weight, and internal browning in bell pepper plants at Fremont, Ohio in 2004.

	TREATMENT	Total Yield (kg)[a]		Marketable Yield (kg)[b]		Estimated Clean (kg)[c]		% ECB-Damaged Fruit[d]		Weight / Fruit (g)		Internal Browning[e]	
1	AI 11005, half rate, 12.87 km/h	11.27	a*	10.77	a	9.33	a	2.3	a	333	a	2.75	ab
2	TJ60-11003, half rate, 6.44 km/h	9.81	ab	9.31	ab	8.52	a	0.0	a	306	a	1.75	bc
3	AI 110025, half rate, 6.44 km/h	9.21	ab	9.21	ab	8.59	a	0.0	a	305	a	1.00	c
4	AI 110025, full rate, 6.44 km/h	8.31	abc	8.06	abc	7.56	ab	0.8	a	299	a	0.75	c
5	Mity Mist, half rate, 12.87 km/h	8.19	abc	7.94	abc	6.57	ab	1.5	a	285	a	3.50	a
6	TJ60-11006, half rate, 12.87 km/h	7.85	bc	7.85	abc	7.00	ab	5.0	a	272	a	1.25	bc
7	Mity Mist, half rate, 6.44 km/h	7.40	bc	7.15	bcd	6.63	ab	2.8	a	299	a	1.00	c
8	Electrostatic, half rate, 6.44 km/h	5.88	c	5.88	c	5.02	b	4.5	a	284	a	1.50	bc
9	Control	1.22	d	1.22	d	0.75	c	20.0	a	180	b	0.50	c
	LSD	3.14		3.24		2.99		11.9		69		1.72	
	P-value	<.0001		0.0003		0.0002		0.0526		0.0107		0.0250	

[a]Total yield is the total weight of all harvested fruit per plot.
[b]Marketable yield is the total weight of all the harvested fruit per plot with a good external appearance.
[c]Estimated clean yield is the total yield multiplied by the percentage of clean fruit per plot.
[d]ECB stands for European corn borer, *Ostrinia nubilalis* (Hübner)
[e]Internal browning is a discoloration or moldy growth inside the fruit which is suspected to be caused by *Alternaria* sp.
*Means separated within columns by LSD, $P \leq 0.05$. Means with common letter do not differ significantly.

Figure 1. Spray Tracer (food coloring) deposits by application technology on bell pepper cv. 'Socrates' leaves at two plant elevations at Fremont, Ohio in 2004.

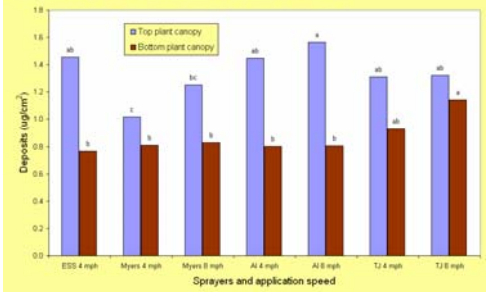

Figure 2. Spray Tracer (food coloring) deposits by application technology on bell pepper cv. 'Socrates' leaves at two plant elevations at Fremont, Ohio in 2004 and 2005.

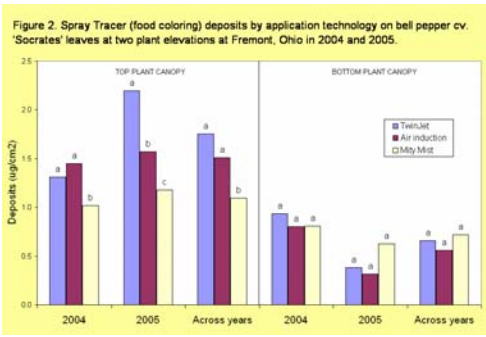

Table 2. Effect of row arrangement, plant stand density, and pesticide application technology on yield and selected variables for green plus red fruit in bell pepper plants at Fremont, Ohio in 2005.

TREATMENT	Total Yield (kg)[a]	Marketable Yield (kg)[b]	Estimated Clean Yield (kg)[c]	Weight / Fruit (g)	Mean Number of Fruit / Plot			
					Caterpillars[d]	Interior Browning[e]	Sunscald	Anthracnose
Row Type (RT)								
Single Row	16.3 a*	13.4 a	12.0 a	186 a	8.5 a	5.2	2.9 a	2.9
Twin Row	9.3 b	7.6 b	7.1 b	177 a	5.0 b	1.6	2.1 a	1.6
LSD	1.5	1.3	1.3	13	1.4	1.2	0.9	0.9
P-value	<0.0001	<0.0001	<0.0001	0.1991	<0.0001	<0.0001	0.0658	0.0068
Plant Stand Density (PS)								
High (14,697 plants/acre)	14.5 a	11.8 a	10.8 a	183 a	6.5 a	4.1	3.0 a	3.6
Medium (10,454 plants/acre)	13.2 a	10.6 ab	9.6 ab	191 a	6.3 a	4.3	2.5 a	2.2
Low (7,049 plants/acre)	10.8 b	9.1 b	8.2 b	172 a	7.5 a	1.8	2.0 a	1.0
LSD	1.9	1.6	1.6	16	1.7	1.4	1.1	1.1
P-value	0.0008	0.0046	0.0080	0.0797	0.3058	0.0014	0.2186	0.0001
Application Technology (AT)								
TJ60	14.6 a	12.3 a	11.8 a	176 a	5.4 b	3.5	2.8 a	2.0
AI	12.9 ab	10.5 b	9.7 b	179 a	5.8 b	3.2	2.6 a	2.6
No Application	11.1 b	8.7 c	7.2 c	190 a	9.2 a	3.5	2.1 a	2.2
LSD	1.9	1.6	1.6	16	1.7	1.4	1.1	1.1
P-value	0.0022	0.0002	<0.0001	0.1987	<0.0001	0.0910	0.4812	0.5220
Coefficient of Variation	25	26	28	16	45	73	75	84
Interactions								
RT x PS	NS	NS	NS	NS	NS	NS	NS	NS
RT x AT	NS	NS	NS	NS	NS	NS	NS	NS
PS x AT	NS	NS	NS	NS	NS	NS	NS	NS
RT x PS x AT	NS	NS	NS	NS	NS	0.0266	NS	0.0326

[a]Total yield is the total weight of all harvested fruit per plot.
[b]Marketable yield is the total weight of all the harvested fruit per plot with a good external appearance.
[c]Estimated clean yield is the total yield multiplied by the percentage of clean fruit per plot.
[d]Caterpillars were European corn borer, *Ostrinia nubilalis*; fall armyworm, *Spodoptera frugiperda*; and corn earworm, *Helicoverpa zea*.
[e]Internal browning is a discoloration or moldy growth inside the fruit which is suspected to be caused by *Alternaria* sp.
*Means separated within columns by LSD, $P \leq 0.05$. Means with common letter do not differ significantly.

Discussion

- Relatively wet, cloudy, and cold climatic conditions in 2004 and very dry, hot weather in 2005 slowed the growth of bell pepper plants and might have had an impact on pesticide deposition patterns on leaf surface.
- Plots treated by the ESS, air-assist, electrostatic sprayer had the lowest yield, but spray deposits on leaves were just as good as others especially at the top canopy.
- The 40 mph outlet air speed produced by the air-assist sprayer might have blown the spray deposits past the target.
- Early trial termination in 2005 might have influenced results by underestimating the cumulative damage.
- TwinJet nozzles were best for targeting applications at the bottom of the bell pepper canopy, but in a year with more vigorous plant growth, the same trend might not apply.
- Greater yields in single rows than in twin rows, at comparable plant stand densities, suggest the possibilities that plants in single rows might have had a micro-environment more conducive to high yields or that pesticide applications were more effective than in twin rows.
- Greater yields at high plant stand density obtained in this study were in accord with findings reported by other researchers.

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