Optimizing Rowcover Deployment for Managing Bacterial Wilt and Using Compost for Organic Muskmelon Production

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Summary. The goal of this study was to develop a systems-based strategy for organic muskmelon (*Cucumis melo* var. *reticulatus*) in Pennsylvania (PA), Iowa (IA), and Kentucky (KY) to manage bacterial wilt (*Erwinia tracheiphila*) and nutrients while safeguarding yield and enhancing early harvest. Spunbond polypropylene rowcovers deployed for different timings during the growing season were evaluated for suppressing bacterial wilt and locally available compost was applied based on two different estimated rates of mineralization of organic nitrogen (N) to manage nutrients. In KY only, the use of rowcovers suppressed bacterial wilt incidence compared with not using rowcovers. However, the timing of rowcover removal did not impact wilt incidence. Under lower cucumber beetle [striped cucumber beetle (*Acalymma vittatum*) and spotted cucumber beetle (*Diabrotica undecimpunctata howardi*)] pressure in PA and IA, rowcovers did not consistently suppress season-long incidence of bacterial wilt. In four of five site-years in PA and IA, more marketable fruit were produced when rowcovers were removed 10 days after an action threshold (the date the first flower opened in PA; the date when ≥50% of plants in a subplot had developed perfect flowers in IA and KY) than when no 10-day delay was made or when no rowcovers were used. In addition, the no-rowcover treatment consistently had lower weight per marketable fruit. In KY, the same action threshold without the 10-day delay, followed by insecticide applications, resulted in the largest number of marketable fruit, but did not affect marketable fruit weight. In PA, marketable yield was higher using compost compared with the organic fertilizer in 1 year. No yield differences were observed by nutrient treatments in 2 years. In IA, marketable yield was lower with the low amount of compost compared with the organic fertilizer and yields with the high amount of compost were not different from the low amount or the organic fertilizer in the year it was evaluated. In KY, marketable yield was unaffected by the nutrient treatments in the year it was evaluated. Given these results, muskmelon growers in PA, IA, and KY who use compost may choose the lower compost rate to minimize production costs. Overall, these findings suggest that rowcover-based strategies for organic management of bacterial wilt need to be optimized on a regional basis, and that fertilization with compost is compatible with these strategies.

Muskmelon is grown on >70,000 acres in the United States, generating >$319 million [U.S. Department of Agriculture (USDA), 2014]. Direct marketing of muskmelon is well suited for diversified organic farms in the eastern half of the United States. The U.S. organic industry continues to expand, with organic food sales increasing nearly 8% in 2010 [Organic Trade Association (OTA), 2011] and valued at over $39 billion in 2014 (OTA, 2015).

In much of the eastern half of the United States, muskmelon growers rank the cucumber beetle/bacterial wilt complex as their most important pest problem (Bessin et al., 2003; Hoffmann, 1999). Striped and spotted cucumber beetles can cause direct feeding damage and vector *E. tracheiphila*, the causal agent of bacterial wilt of cucurbits. Bacterial wilt can reduce yields by 80% on unprotected muskmelon (Sherf and MacNab, 1986) and cucumber [*Cucumis sativus* (Latin, 1993)] and is also a serious threat to pumpkin (*Cucurbita maxima*), winter squash (*Cucurbita* sp.), and zucchini (*Cucurbita pepo*) (McGrath, 2001).

On conventional farms, insecticides are the primary tool for bacterial wilt control. Recommendations for timing of insecticide applications in conventional production vary from calendar-based timing beginning at plant emergence (Sánchez et al., 2013) to sprays based on cucumber beetle scouting thresholds. Unfortunately, the few insecticides available to organic growers are largely not highly effective against cucumber beetles.

Spunbond polypropylene rowcovers exclude cucumber beetles and other insect pests (Bextine et al., 2001; Perring et al., 1989; Saalau Rojas et al., 2011), thereby eliminating the need for insecticide applications during the protected period. Rowcovers are often used to accelerate crop development and protect against environmental extremes from transplant until flowers appear (Soltani et al., 1995; Taber, 1993). In IA, removing rowcovers at bloom temporarily suppressed bacterial wilt in muskmelon, but this effect was overcome once covers were removed and plants were exposed to cucumber beetles (Mueller et al., 2006). Interestingly, delaying rowcover removal in IA until 10 d after perfect flowers appeared resulted in bacterial wilt incidence of <20% at harvest compared with >80% without the 10-d delay (Saalau Rojas et al., 2011). However, to determine the value of this strategy to organic producers it must be field tested in regions with different climates and levels of bacterial wilt and cucumber beetle pressure. Pest exclusion must also be balanced with providing pollinator access, since muskmelon requires insect pollination and rowcovers exclude pollinators.

In addition to pest control, nutrient management can be challenging

Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
0.4047	acre(s)	ha	2.4711
102.7902	acre-inch(es)	m^3	0.0097
0.3048	ft	m	3.2808
2.54	inch(es)	cm	0.3937
0.4536	lb	kg	2.2046
1.1209	lb/acre	$kg \cdot ha^{-1}$	0.8922

on organic farms (Clark et al., 1999; Pimentel et al., 2005), in part because nutrient sources generated on the farm, such as compost, release nutrients slowly. Nutrient availability is also unpredictable; for example, N mineralization rates depend on soil temperature, microbial activity, and organic matter incorporation (Richard, 2004). Combining organic nutrient sources such as compost with rowcovers can also increase yields by contributing to vegetative plant growth characteristics (Nair and Ngouajio, 2010).

The goal of the present study was to develop a coherent management approach for bacterial wilt and using compost for organic muskmelon production in PA, IA, and KY. We investigated the single and combined effects of various rowcover timing strategies and compost application rates on bacterial wilt incidence and marketable yield.

Materials and methods

Study sites included Pennsylvania State University's Russell E. Larson Agriculture Research Center in Pennsylvania Furnace, PA; Iowa State University's Horticulture Research Station in Ames, IA; and University of Kentucky's Horticulture Research Farm in Lexington, KY (Table 1). Fields were managed according to the National Organic Standards (USDA, 2015) in PA and IA, and were certified organic in KY. Studies occurred from 2009 to 2011 in PA, and 2010 to 2012 in IA and KY. 'Strike Premium' muskmelon seeds were donated by Seedway (Elizabethtown, PA). Seedway reports this cultivar to have high resistance to *Fusarium oxysporum* f. sp. *melonis* (races 0, 1, and 2) and *Sphaerotheca fuliginea* (race 1). Dates and other details of the experiments, including experimental design, transplant and harvest dates, in- and between-row spacings, rowcover material, installation and deployment, pest management strategies, and nutrient management treatments, are presented in Table 1.

Nutrient treatments were broadcast and soil incorporated within 24 h (Table 1). Compost feedstocks were dairy or horse manure and plant residues. Compost treatments were based on supplying 75 lb/acre N in PA and KY and 80 lb/acre N in IA using estimating mineralization rates of organic nitrogen; a 10% mineralization rate (higher volume) and a 30% mineralization rate (lower volume) were used. Volumes of compost applied were calculated using the amount of organic and ammonium nitrogen in the compost (Sánchez and Richard, 2009). Organic bagged fertilizer was applied as a control treatment.

Two- to 4-week-old muskmelon transplants were planted on raised beds with a single drip irrigation line and covered with black plastic mulch (Table 1). The irrigation system supplemented natural rainfall to attain a total of 1.0 to 1.5 acre-inches of water per week. Spunbond rowcovers (Agribon®, Mooresville, NC) were installed within 24 h after transplant. Wire support hoops were spaced 4 to 5 ft apart and rowcover edges were secured (Table 1). Weeds were managed with either a 4- to 6-inch layer of organic mulch or cultivation (Table 1).

Rowcover treatments in each state were based on management needs for that region; some treatments were also modified in subsequent years on the basis of results in earlier years (Table 2). A no rowcover treatment with no insecticides (NRC) served as a common control in all site-years. The timing of removal of rowcovers was based on the onset of a locally defined date of anthesis; in IA and KY, anthesis was defined as the first date when ≥50% of plants had perfect flowers in bloom, whereas in PA it was defined as the time when the first flower (typically staminate) opened. Rowcovers were removed either at anthesis (RCA) or 10 d later (RC10). In KY and IA, another treatment opened rowcover ends at anthesis to allow pollinator access, followed by complete removal 10 d later (RCOE). After covers were removed, differences among site-years in cucumber beetle pressure dictated different patterns of certified organic approved insecticide use.

Cucumber beetle populations in PA and IA were always below threshold (<1 beetle/plant), so no insecticide sprays were applied against these pests. In IA, however, pyrethrum (Pyganic; MGK, Minneapolis, MN) was sprayed near harvest to manage high populations of picnic beetles (*Glischrochilus quadrisignatus*) and copper hydroxide (Champ 50 WG; NuFarm Americas, Burr Ridge, IL) was applied as needed to manage anthracnose (*Colletotrichum orbiculare*). In KY, muskmelon crops are subjected to intense season-long cucumber beetle pressure compared with PA and IA, as determined by observational and plant mortality assessments. High cucumber beetle populations required the use of insecticides, including pyrethrum, kaolin clay (Surround; Tessenderlo Kerley, Phoenix, AZ), and neem oil (Trilogy; Certis USA, Columbia, MD). Two additional treatments were assessed in KY in anticipation of high season-long bacterial wilt risk: 1) on-off-on (OOO), where rowcovers were removed at the action threshold for a 2-week-long period during which pollinators could access flowers and insecticides were applied late in the evening after pollinators returned to their hives, then rowcovers were replaced until harvest began and 2) rowcovers were removed at the action threshold followed by treating plants with *Pseudomonas fluorescens* A506 (Blight Ban A506; NuFarm, Dublin, OH) and insecticides for the duration of the season (RCA + *Pf*). Blight Ban was used in this treatment because it can suppress epiphytic populations of the fire blight pathogen *Erwinia amylovora* (Momol et al., 1999), and therefore was hypothesized to suppress epiphytic populations of the related bacterium *E. tracheiphila* (Saalau Rojas and Gleason, 2012).

Data collection. Incidence (percent wilted plants) of bacterial wilt was assessed weekly in PA and IA from mid-July to mid-August by

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Table 1. Details and dates of field experiments conducted in Pennsylvania, Iowa, and Kentucky during 2009–12 to evaluate timing or rowcover removal and nutrient management with compost for organic muskmelon.

Objective	Specifications	Pennsylvania	Iowa	Kentucky
	Location	lat. 40°42′N long. 77°7′W	lat. 42°6′N long. 93°35′W	lat. 37°98′N long. 84°53′W
	Experimental design	All years: split plot 3 × 3, N = 5	2010: split plot 3 × 3, N = 4 2011, 2012: randomized complete block, N = 4	2010: split plot randomized complete block 3 × 4, N = 4 2011, 2012: randomized complete block, N = 4
	Transplant date	19 June 2009 21 June 2010 15 June 2011	27 May 2010 17 May 2011 17 May 2012	31 May 2010 10 May 2011 24 May 2012
	Spacing within row (ft)[z]	1.5	2	1.5
	Row centers (ft)	8	8	5
Rowcovers	Rowcover product	Agribon®AG-19 (Agribon, Mooresville, NC)	Agribon®AG-30	Agribon®AG-19
	Support hoops	Spring steel[y]	Spring steel	Preformed 10-gauge wire
	Securing of edges	Landscape pins	Buried with field soil	Buried with field soil
	Timing of removal	When first flower appeared	When ≥50% of plants had perfect flowers	When ≥50% of plants had perfect flowers
	Pesticides	None	Pyrethrum, copper hydroxide	Pyrethrum, kaolin clay, neem oil
	Weed management	Wheat straw mulch; 4–6 inches[z] deep	Corn stover mulch; 4–6 inches deep	Cultivation
	Harvest dates (at full slip)	2009: 31 Aug.; 4, 10, 17 Sept. 2010: 16, 20, 26, 31 Aug. 2011: 12, 23, 30 Aug.	2010, 2011: 2× weekly 2012: daily	2010: 29 July; 3, 9 Aug. 2011: 12, 15, 19 Aug. 2012: 23, 28 Jul.; 3 Aug.
Nutrient management	Years conducted	2009–11	2010	2010
	Nitrogen rate (lb/acre)[z]	75	80	75
	Bagged fertilizer control	Blue N 5N–0.4P–0.8K (Fertrell Co., Bainbridge, PA)	3N–1.7P–5.8K (Fertrell Co.)	Earth-friendly all-purpose 5N–1.3P–2.5K (Fertrell Co.)
	Compost	Dairy and plant residual based	Dairy manure based	Cow and horse manure and horse bedding based
	Dates nutrients applied	16 June 2009 16 June 2010 9 June 2011	12 May 2010	27 May 2010

[z]1 ft = 0.3048 m, 1 inch = 2.54 cm, 1 lb/acre = 1.1209 kg·ha^{-1}.
[y]Spring steel hoops [64 inches (RCHW64; Advancing Alternatives, Schuylkill Haven, PA)].

counting individual plants expressing symptoms. In KY, weekly assessments began ≈3 weeks after planting and continued through harvest.

At harvest, fruit were categorized as marketable or unmarketable, then counted, and weighed. Nonmarketable fruit were diseased, cracked, <2 lb, or damaged by insects.

Experimental design and statistical analysis. Experimental design varied among states and years depending on regional differences in pest pressure and grower practices (Table 1). In IA and KY, changes were undertaken in years 2 and 3 to better fit the experimental design to the circumstances in each state. Given an absence of compost-related effects in year 2, compost treatments were collapsed in those locations. In addition, it became clear that different rowcover strategies, including season-long deployment of rowcovers, was a logical option in KY, with its intense season-long bacterial wilt pressure, but not in PA or IA, where the risk of bacterial wilt was confined mainly to early-season outbreaks.

In PA, a split plot was arranged as a 3 × 3 factorial with five replications; main plots consisted of three rowcover treatments and were 200-ft-long × 2.5-ft-wide rows, and subplots were 35-ft-long × 20-ft-wide areas within a row. Compost treatments (three levels) were applied to subplots. In IA, during 2010, a split-plot design was arranged as a 3 × 3 factorial with four replications. Main plots were 30 × 72 ft and consisted of three compost treatments, as in PA. Rowcover treatments (three levels) were applied to each 30-ft-long subplot. During 2011 and 2012, the IA plot design was altered; compost treatments were no longer evaluated, and

Table 2. Incidence of bacterial wilt of organic muskmelon on the date of first harvest for field experiments evaluating timing of rowcover removal in Pennsylvania, Iowa, and Kentucky in 2009 –12.

Yr[z]	Rowcover treatment[y]	Pennsylvania	Iowa	Kentucky
		Symptomatic plants (%)		
1	NRC	9.4 a[x]	0 a	55.2 a
	RCA	10.0 a	0 a	1.9 b
	RC10	5.6 a	NT[w]	NT
	RCOE	NT	0 a	2.3 b
	OOO	NT	NT	0 b
2	NRC	—[v]	0.7 a	50.0 a
	RCA	—	0.5 a	4.0 b
	RC10	—	0.3 a	NT
	RCOE	NT	0.3 a	NT
	OOO	NT	NT	2.0 b
	RCA + *Pf*	NT	NT	2.0 b
3	NRC	17.3 ab	5.0 a	50.0 a
	RCA	22.7 a	4.2 a	7.8 b
	RC10	10.3 b	3.9 a	NT
	RCOE	NT	3.8 a	NT
	OOO	NT	NT	23.4 b
	RCA + *Pf*	NT	NT	10.5 b

[z]Experiments were conducted during 2009 (year 1), 2010 (year 2), and 2011 (year 3) in Pennsylvania; during 2010 (year 1), 2011 (year 2), and 2012 (year 3) in Iowa and Kentucky.
[y]NRC = no rowcover and no insecticides; RCA = rowcovers removed at action threshold; RC10 = rowcovers removed 10 d after reaching the action threshold; RCOE = rowcover ends opened at the action threshold, then rowcovers where removed entirely 10 d later; OOO = rowcovers removed at the action threshold, then reinstalled 2 weeks later, insecticide sprays applied during the uncovered period (on-off-on); RCA + *Pf* = rowcovers removed 10 d after anthesis, followed by applications of insecticides (pyrethrum, kaolin clay and neem oil) and *Pseudomonas fluorescens* A506; in Pennsylvania, the rowcover removal action threshold was defined as the date of the appearance of open flowers; in Kentucky and Iowa, it was defined as the date when ≤50% of plants had perfect flowers in bloom.
[x]Within each year, means in a column followed by the same letters are not significantly different using Fisher's protected least significant difference at $P \leq 0.05$.
[w]Treatment was not tested in this site-year.
[v]Flowers appeared before transplanting occurred, which prevented the rowcover action threshold-prescribed timing of rowcover removal during this site-year.

a rowcover treatment (RC10) was added to maintain a randomized complete block. In KY, during 2010, a split-plot design was arranged as a 3 × 4 factorial with four replications. Main plots consisted of three compost treatments and subplots contained four rowcover treatments. Each main plot (compost) was 300 ft long and each subplot (rowcover) was 75 ft long, consisting of four 15-ft-long treatments with 5 ft between adjacent treatments. As in IA, compost treatments were not compared during 2011 and 2012. Another change during these years was that each subplot contained three rows rather than one as in 2010.

Yield data (expressed as mean number of marketable and unmarketable fruit per plant, and mean weight of marketable fruit per plant) were analyzed by site-year, using Fisher's protected least significant difference (LSD) at $P \leq 0.05$. For bacterial wilt incidence, treatments were compared using Fisher's protected LSD ($P \leq 0.05$).

Results and discussion

Impact of action threshold on trial outcomes. Differences in criteria for the rowcover removal action threshold impacted trial outcomes. Anthesis was defined in PA as the date of appearance of the first flower; in contrast, KY and IA defined anthesis as the first date when ≥50% of plants in a subplot had developed perfect flowers. In PA in 2010, spring rain prevented timely entry into the field and resulted in seedlings developing flowers before transplanting; anthesis, as defined in PA, occurred before rowcovers were installed, preventing comparisons among rowcover treatments in that site-year. Determining how to define anthesis for optimal rowcover removal may depend on several factors, including ease of implementation and growers' marketing requirements, in addition to pest and disease management needs. Under translucent spunbond rowcovers, for example, it is easier for growers to notice the first appearance of yellow blossoms than to discriminate between staminate and perfect flowers. Furthermore, the typically earlier removal of rowcovers associated with defining anthesis as the appearance of the first flower can result in earlier yield than when defining anthesis as when 50% of plots have perfect flowers due to earlier pollination and can thus secure higher prices in some markets. On the other hand, because the appearance of first flowers can be triggered by certain environmental conditions, even before transplanting, whereas perfect flowers appear in a more consistent phenological pattern, the latter definition of anthesis is likely to be a more consistent guide to timing rowcover removal.

Bacterial wilt incidence. Postponing rowcover removal for 10 d after the action threshold (treatments RC10 and RCOE) delayed the onset of bacterial wilt in PA in 2009 and 2011, and in IA in 2011 (data not shown). At harvest, however, bacterial wilt incidence was similar among rowcover treatments, except in PA during 2011, when delaying rowcover removal for 10 d resulted in significantly ($P < 0.05$) lower incidence than the standard-practice treatment of removing rowcovers at the action threshold (Table 2). Bacterial wilt was not detected in IA trials in 2010, and appeared at very low levels in 2011 and 2012, presumably associated with very low populations of cucumber beetles observed during those years. In KY, incidence of bacterial wilt mortality in the NRC control treatment ranged from 50.0% to 55.2%, whereas plots with rowcovers had significantly ($P < 0.05$) lower incidence of the disease (Table 2). Bacterial wilt mortality did not differ among the rowcover treatments, regardless of timing of cover removal. In KY, unacceptably high plant mortality in the NRC treatment indicated that cucumber beetle management must start at transplant for successful production of organic muskmelon.

Impacts on yield. The use of rowcovers generally resulted in higher marketable yield (Table 3). The NRC control produced the fewest ($P < 0.05$) marketable fruit per plant except in IA and PA during 2010, when the NRC treatment was not different

Table 3. Effect of the timing of rowcover removal on mean number of marketable and unmarketable fruit per plant, and mean weight per marketable fruit for organic muskmelon field experiments in Pennsylvania, Iowa, and Kentucky in 2009–12.

		Pennsylvania			Iowa			Kentucky		
Yr[z]	Rowcover treatment[y]	Marketable fruit (no./plant)	Unmarketable fruit (no./plant)	Marketable fruit (lb/plant)[x]	Marketable fruit (no./plant)	Unmarketable fruit (no./plant)	Marketable fruit (lb/plant)	Marketable fruit (no./plant)	Unmarketable fruit (no./plant)	Marketable fruit (lb/plant)
1	NRC	0.4 c[w]	1.5 b	4.2	0.8 b	0.6 b	4.3	0.6 d	1.0 b	4.6 ab
	RCA	0.5 b	1.8 a	4.2	1.0 a	0.8 a	4.2	1.6 a	0.9 b	4.4 ab
	RC10	1.5 a	1.2 c	4.0	NT	NT	NT	NT	NT	NT
	RCOE	NT[v]	NT	NT	1.0 a	0.8 a	4.3	1.3 b	0.9 b	4.7 a
	OOO	NT	NT	NT	NT	NT	NT	0.9 c	1.5 a	4.0 b
2	NRC	—[u]	—	—	1. 1b	0.4	5.4 a	0.6 c	0.4 ab	5.2
	RCA	—	—	—	1.3 ab	0.5	4.7 ab	1.4 a	0.2 bc	5.3
	RC10	—	—	—	1.6 a	0.4	5.0 ab	NT	NT	NT
	RCOE	—	—	—	1.4 a	0.4	4.4 b	NT	NT	NT
	OOO	—	—	—	NT	NT	NT	1.1 b	0.5 a	5.1
	RCA + *Pf*	—	—	—	NT	NT	NT	1.3 ab	0.2 c	5.2
3	NRC	1.3 b	0.5	4.0	2.4 c	0.3	4.2 a	0.5 c	0.6 a	5.5
	RCA	1.2 b	0.5	3.8	3.2 b	0.3	4.3 a	2.1 a	0.6 a	5.4
	RC10	1.7 a	0.6	4.0	4.2a	0.3	3.2 b	NT	NT	NT
	RCOE	NT	NT	NT	4.0a	0.3	4.0 a	NT	NT	NT
	OOO	NT	NT	NT	NT	NT	NT	1.6 b	0.4 c	5.5
	RCA + *Pf*	NT	NT	NT	NT	NT	NT	2.2 a	0.5 b	5.2

[z]Experiments were conducted during 2009 (year 1), 2010 (year 2), and 2011(year 3) in Pennsylvania; during 2010 (year 1), 2011 (year 2), and 2012 (year 3) in Iowa and Kentucky.
[y]NRC = no rowcover and no insecticides; RCA = rowcovers removed at action threshold; RC10 = rowcovers removed 10 d after reaching the action threshold; RCOE = rowcover ends opened at the action threshold, then removed entirely 10 d later; OOO = rowcovers removed at the action threshold, then reinstalled 2 weeks later; insecticide sprays applied during the uncovered period (on-off-on); RCA + *Pf* = rowcovers removed 10 d after reaching the rowcover action threshold, followed by applications of insecticides and *Pseudomonas fluorescens* A506; in Pennsylvania, the rowcover action threshold was defined as the date of the appearance of open flowers; in Kentucky and Iowa, it was defined as the date when ≤50% of plants had perfect flowers in bloom.
[x]1 lb = 0.4536 kg.
[w]Within each year, means within a column followed by the same letters are not significantly different using Fisher's protected least significant difference at $P \leq 0.05$.
[v]Treatment was not tested in this site-year.
[u]Flowers appeared before transplanting, which prevented the rowcover action threshold-prescribed timing of rowcover removal during this site-year.

from the treatment in which rowcovers were removed at the action threshold (RCA). The yield impact of delaying rowcover removal for 10 d beyond the action threshold date differed among site-years. Treatments with a 10-d delay in rowcover removal after the action threshold (RC10 and RCOE) sometimes had more (P < 0.05) marketable fruit than removal at the action threshold (PA in 2009 and 2011, IA in 2012), but resulted in no difference in other site-years (IA in 2010 and 2011) and significantly fewer fruit in one site-year (KY in 2010). For KY, the RCA treatment consistently gave the highest (P < 0.05) marketable yield. Application of *P. fluorescens* did not raise marketable yield compared with the RCA treatment.

In KY, the OOO rowcover treatment resulted in fewer (P < 0.05) marketable fruit than the other rowcover treatments. One factor that may have contributed to this result is inadequate pollination, since the time window for pollination was only 2 weeks long which was several weeks less than for other treatments. Furthermore, air temperatures under the season-long rowcovers may have exceeded optima for plant growth and development during midsummer in KY. Finally, organic insecticides provided only partial control of cucumber beetles during the exposure period, possibly facilitating feeding injury and bacterial wilt development once covers were redeployed.

The impact of delaying rowcover removal on early harvest was variable. In PA, RC10 had the most (P < 0.05) fruit at first harvest in all years. In IA, however, RCA had the highest early-season yield in all years. In KY, there were no notable differences among rowcover treatments in earliness of harvest (data not shown).

Effect of compost treatments on yield. Impact of the compost treatments on yield varied among site-years. In PA, marketable fruit number was increased in 2009 when using the high amount of compost compared with the organic fertilizer (control) and when using the low amount of compost compared with the control. In 2010 and 2011, no significant differences were observed in yield by nutrient treatments (data not shown).

In IA, the number of marketable fruit was lower when applying the low amount of compost (12.3 fruit/plot) compared with applying organic fertilizer (16.6 fruit/plot) in 2010. Applying the high amount of compost resulted in marketable fruit numbers (14.3 fruit/plot) not different from the other two treatments.

In KY, in 2010, the number of marketable fruit was unaffected by the nutrient treatments [11.8 fruit/plot (organic fertilizer), 9.2 fruit/plot (low amount of compost), 9.7 fruit/plot (high amount of compost)]. Given these results, muskmelon growers who use compost as their fertilizer source may choose to base application on the higher estimated mineralization rate (lower amount) to minimize production costs.

Conclusions

Although differences in cucumber beetle pressure, climate and prevailing grower practices warranted implementation of region-specific experimental protocols in each state, several common themes emerged. First, rowcovers generally increased marketable yield, apparently due to both bacterial wilt suppression and modification of the growing environment. Imposing a 10-d delay in rowcover removal suppressed bacterial wilt and improved marketable yield in some site-years (PA in 2009 and 2011, IA in 2012) but not others. In the 2012, IA trial, the fact that delayed rowcover removal had the highest marketable yields even in the absence of significant bacterial wilt pressure suggests that prolonging the rowcovered period can confer benefits beyond wilt suppression, by mitigating weather damage to the crop and suppressing fungal diseases such as anthracnose (*C. orbiculare*). KY trials presented a contrasting scenario of high cucumber beetle populations and bacterial wilt risk during the entire growing season; under these circumstances, a 10-d delay in rowcover removal was counterproductive, and new strategies to provide season-long protection need to be developed. Pre-plant compost application fit well with rowcover use, but our results suggested that our lower rate of application was adequate; application to other sites would require preplant testing to confirm soil nutrient status.

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