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Differential Occurrence of Bacterial Wilt in Muskmelon Due to Preferential Striped Cucumber Beetle Feeding

Gerald E. Brust[1] and Karen K. Rane[2]

Purdue University, Southwest Purdue Agriculturul Research Center R.R. 6, Box 139A, Vincennes, IN 47591

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Abstract. **Ten muskmelon *(Cucumis melo* L.) cultivars were tested for their susceptibility to bacterial wilt, caused by *Erwinia trucheiphila* (Smith) Bergey, Harrison, Breed, Hammer and Huntoon and vectored by the striped cucumber beetle *Acalymma vittatum (F).* 'Superstar', 'Rising Star', 'Pulsar', 'Caravelle', 'Cordele', 'Legend', 'Makdimon', 'Galia', 'Rocky Sweet', and 'Passport' were used in field studies to determine the number of striped cucumber beetles, feeding damage, and incidence of bacterial wilt. 'Makdimon' and 'Rocky Sweet' hosted significantly more beetles than the other cultivars. These two cultivars and 'Legend' and 'Cordele' had much more feeding damage and a significantly higher incidence of bacterial wilt than the others. A greenhouse experiment was conducted with seven of the cultivars to test their susceptibility to bacterial wilt when directly inoculated with the causal agent. All cultivars were equally susceptible to the disease when it was introduced directly into the plant. Selective feeding by striped cucumber beetles was probably most responsible for 'Makdimon', 'Rocky Sweet', 'Legend', and 'Cordele' having greater incidences of bacterial wilt than the other cultivars.**

One of the most devastating diseases in muskmelon is bacterial wilt. Once a plant starts to wilt due to the disease, there is no control (Sherf and MacNab, 1986). Thecausal organism, *Erwinia tracheiphila*, is vectored by the striped cucumber beetle. The bacterium is believed to overwinter in the gut of the adult beetle (York, 1992). In spring, beetles become active and begin to feed on cucurbit plants. Beetles can appear in a matter of 6 to 12 h in large numbers in newly planted cucurbit fields. Their densities can be ≥ 75 per plant in some areas of a field (Brust and Foster, 1995). The striped cucumber beetle transmits the pathogen to wounds created when it feeds on cucurbits; the beetle deposits fecal material containing the bacteria where it feeds (Leach, 1964). The bacterial pathogen in the feces of the beetle then enters the plant (Rand, 1916).

In fields with several cultivars of muskmelon, some cultivars suffered 50% to 80% bacterial wilt infection, but others had much lower percentages. The disease is managed by applying foliar insecticide to prevent the beetles from vectoring the pathogen (Foster, 1992). However, beetles can rapidly infest fields and may feed for several days before the grower notices their presence. This slow detection of beetles can lead to high levels of wilt.

Two plausible explanations for the difference in levels of wilt incidence among muskmelon cultivars are 1) certain cultivars are more attractive to striped cucumber beetles and beetles selectively feed more heavily on these cultivars, and 2) certain cultivars are more susceptible to the bacterium once it enters the plant. To discern which could be a valid hypothesis, a series of field and greenhouse studies were conducted.

Materials and Methods

Field experiments were conducted at the Southwest Purdue Agricultural Research Center in southwestern Indiana. The soil type was a sandy loam with a pH of 6.8. Ten muskmelon cultivars commonly grown in southwestern Indiana were included in the study: 'Passport', 'Rocky Sweet', 'Superstar', 'Pulsar', 'Caravelle', 'Rising Star', 'Galia', 'Legend', 'Cordele', and 'Makdimon'. Plants were seeded in the greenhouse and transplanted to the field at the three-leaf stage on 4 May 1993. Field studies were arranged in a randomized complete-block design with five replications. Treatments were the 10 cultivars. Each plot was a single row, 20 m long. Black plastic was laid 1 week before transplants were set in the field. There was 1.3 m between plants within a row, 15 plants per row. No insecticides were used. After transplanting, plants were checked daily (between 1000 and 1400 HR) for number of beetles and the amount of feeding damage on each plant. A scale of 0 to 5 [0 = no feeding, 1 = little feeding on any leaf, 2 = a few small (0.5 to 3 mm in diameter) feeding holes, 3 = two or three large (>3.0 mm) feeding holes, 4 = several (four to five) large feeding holes, and 5 = more than six large feeding holes] was used to measure feeding severity (Brust and Foster, 1995). On 15 June. plants were examined for symptoms of bacterial wilt. Any wilted plants found were examined for the presence of *E. tracheiphila* bacteria by cutting the base of the stem and bringing the two cut ends back into contact with each other. These cut ends then were pulled apart slowly, and the presence of a white viscous string was diagnostic for bacterial wilt (Latin, 1993).

To verify field observations, the six cultivars that had the highest incidence of beetle feeding were used in the greenhouse studies; in addition, 'Superstar' was used as a comparison because it is the most widely grown melon cultivar in southwestern Indiana. A three to five-leaf plant of each cultivar was placed into a 10-cm-wide × 20-cm-deep plastic pot. Ten pots of each cultivar (total of 70 pots) were randomly distributed in a 1.2 × 1.2 × 1.5-m screened cage. Twenty-four hours after caging, 100 striped cucumber beetles were captured from field plots and released into the cage. This experiment was replicated four times over several days. All plants were checked for number of beetles and rated for feeding damage 6, 12, 24, 48, 72, 96, 120, and 156 h after beetle release.

These same seven cultivars were infected artificially with *E. tracheiphila* in a separate greenhouse study. Inoculum was maintained in 'Superstar' seedlings (two- to three-leaf stage). Inoculum was prepared by grinding 1-cm stem sections from wilted seedlings in 2 ml sterile distilled water. Forty plants, four- to six-leaf stage, were used for each cultivar. Each plant received 0.1 ml of inoculum in one of two inoculation methods. Twenty plants were inoculated by injecting 0.1 ml of inoculum into the lower stem using a syringe with a 22-gauge needle. The remaining 20 plants were inoculated by spreading 0.1 ml of inoculum on the blade of the youngest developed leaf and puncturing ≈10 holes through the aliquot into the leaf blade. Plant leaf surfaces were kept moist for 24 h by periodic overhead irrigation.

A two-way analysis of variance (ANOVA) was run for all field data, and a one-way ANOVA was used for all greenhouse data. Duncan's multiple range test was used to separate means. Correlation analysis was used to discern the relationship between beetle density and feeding damage ratings and percentage of wilt in the field.

Results and Discussion

Beetles invaded the field on 5 May, and populations remained high for the next 6 days (Table 1). Beetle density peaked between 6 and 7 May for all cultivars. 'Makdimon' and 'Rocky Sweet' cultivars hosted the most beetles over the 7 days. These cultivars had more than 3 times as high beetle populations per plant as 'Superstar'. Beetle populations on 'Cordele' and 'Legend' were ≈1.8 times those for 'Superstar'.

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[1]Integrated Pest Management Specialist, Southwest Purdue Agricultural Research Center.

[2]Plant Pathologist, Dept. of Botany and Plant Pathology, Purdue Univ.

Table 1. Mean number of striped cucumber beetles per plant, feeding damage rating (on a scale from 0 = none to = most severe), and percentage of muskmelon plants with bacterial wilt in a field test.

	Date (May)[z]										
	5		6		7		8		9		
Cultivar	Beetles/ plant	Feeding rating	Beetles/ plant	Feeding rating	Beetles/ plant	Feeding rating	Beetles/ plant	Feeding rating	Beetles/ plant	Feeding rating	% Plants with wilt
Makdimon	3.1 a	0.8 a	17.5 a	1.8 a	18.1 a	3.4 a	15.1 a	3.8 a	12.2 a	4.1 a	23.1 a
Rocky Sweet	2.9 a	0.7 a	16.4 a	1.2 ab	12.2 a	3.0 a	10.6 ab	3.8 a	11.1 a	3.9 a	18.9 a
Cordele	1.4 a	0.2 a	8.2 b	1.0 ab	7.6 ab	2.8 a	8.2 bc	3.1 ab	7.2 ab	3.3 a	11.9 b
Legend	1.3 a	0.5 a	8.1 b	1.0 ab	8.9 b	2.6 ab	8.8 a–c	3.0 ab	6.8 ab	3.4 a	9.8 b
Caravelle	1.2 a	0.0 a	5.3 b	0.7 ab	5.7 b	1.2 b	5.3 bc	1.3 b	5.2 ab	1.5 b	4.6 c
Galia	1.1 a	0.0 a	4.4 b	0.8 ab	6.1 b	1.1 b	3.1 bc	1.1 b	5.3 ab	1.5 b	4.4 c
Passport	1.0 a	0.5 a	4.2 b	0.5 b	6.2 b	1.0 b	4.1 bc	1.2 b	5.7 ab	1.5 b	4.6 c
Pulsar	1.0 a	0.3 a	3.1 b	0.7 ab	4.3 b	0.8 b	3.7 bc	1.0 b	4.3 ab	1.4 b	3.9 c
SuperStar	0.8 a	0.0 a	3.2 b	0.0 b	4.6 b	0.7 b	4.5 c	1.1 b	4.0 b	1.2 b	3.0 c
Rising Star	0.7 a	0.0 a	3.3 b	0.1 b	5.1 b	0.3 b	4.2 c	0.9 b	3.9 b	1.0 b	2.6 c

[z]Mean separation by Duncan's multiple range test at $P \leq 0.05$.

Table 2. Mean number of striped cucumber beetles per plant and feeding damage rating (on a scale from 0 = none to 5 = most severe) for seven muskmelon cultivars in a grecnhouse text.

	Hours after beetles were released[z]											
	6		12		24		48		72		96	
Cultivar	Beetles/ plant	Feeding rating	Beetles/ plant	Feeding rating	Beetles/ plant	Feeding rating	Beetles/ plant	Feeding rating	Beetles/ plant	Feeding rating	Beetles/ plant	Feeding rating
Makdimon	1.8 a	1.8 a	2.2 a	3.1 a	1.5 a	3.8 a	1.7 a	4.2 a	1.2 a	4.1 a	1.1 a	4.2 a
Rocky Sweet	1.6 a	1.7 a	1.8 ab	2.8 a	1.3 a	3.6 a	1.4 a	3.7 a	1.4 a	3.7 ab	1.2 a	3.9 ab
Cordele	1.1 ab	0.8 a	1.3 bc	1.6 ab	1.1 b	2.5 ab	1.0 ab	2.6 ab	1.0 ab	3.0 ab	0.8 ab	2.7 ab
Legend	0.9 b	0.9 a	1.0 cd	1.5 ab	1.0 b	2.0 b	1.0 b	2.2 ab	0.9 b	2.8 ab	0.8 ab	2.6 ab
Caravelle	0.4 bc	0.5 a	0.5 d	1.1 b	0.4 b	1.3 bc	0.5 b	1.4 bc	0.5 bc	2.0 b	0.8 b	2.1 ab
Galia	0.4 bc	0.0 a	0.5 cd	1.5 ab	0.5 b	1.3 bc	0.5 b	1.8 bc	0.3 c	2.2 ab	0.6 b	2.0 b
SuperStar	0.2 c	0.0 a	0.3 d	0.5 b	0.4 b	0.6 c	0.6 b	0.9 c	0.4 bc	1.1 b	0.5 b	1.7 b

[z]Mean separation by Duncan's multiple range test at $P < 0.05$

Feeding damage ratings show that 'Makdimon', 'Rocky Sweet', 'Cordele', and 'Legend' had been significantly more fed on than 'Superstar' (Table 1) by the end of the test. The average feeding rating for 'Makdimon' was 3.6; 'Rocky Sweet', 3.1; 'Cordele', 2.7; and 'Legend'. 2.5. The cultivar that received the next most feeding was 'Caravelle', with a 1.3 rating. 'Superstar' and 'Rising Star' had the lowest overall ratings at 0.80. Feeding ratings were 23.0 by 8 May for 'Makdimon', 'Rocky Sweet'. 'Cordele', and 'Legend', but never reached this level for any of the other cultivars.

All cultivars developed some bacterial wilt (Table 1) in the field. 'Makdimon' and 'Rocky Sweet' had a significantly higher incidence of wilt, with 23% and 19% wilted plants, respectively. 'Legend' and 'Cordele' suffered less wilt than 'Makdimon' and 'Rocky Sweet' but more than othercultivars (Table 1). 'Superstar' and 'Rising Star' had the lowest percentage wilt. 'Makdimon', 'Rocky Sweet', 'Cordele'. and 'Legend' developed 7.6, 6.3, 4, and 3.3 times more wilted plants, respectively, than 'Superstar'.

In the greenhouse study, at ≤ 72 h after beetle release, beetles were more abundant on 'Makdimon' and 'Rocky Sweet' than any other cultivar, except 'Cordele' (Table 2). The cultivars Cordele and Legend had an average of 2.3 times more beetles during the first five readings compared to 'Superstar'. At 120 and 156 h, the beetles were evenly distributed on all of the cultivars, and there were no significant differences (data not shown). Mean feeding damage ratings were 3.1 on 'Makdimon' and 2.8 on 'Rocky Sweet' after 12 h (Table 2). It took 96 h for 'Cordele' and 'Legend' and ≈120 h for the other three cultivars to reach near these levels. No cultivars were defoliated in these experiments.

Based on our field and greenhouse tests, striped cucumber beetles preferred to feed on 'Makdimon' and 'Rocky Sweet' muskmelons and, to a lesser extent, on 'Cordele' and 'Legend', when given a choice with other muskmelon cultivars. Beetles appeared to select the 'Makdimon' and 'Rocky Sweet' cultivars quickly. Within 6 h, they had begun to amass on them in the greenhouse study. The beetles preferred to feed on 'Makdimon' and 'Rocky Sweet' 24 h after they first appeared in the field. There may be visual or odor stimuli and feeding or tactile cues that cause the beetles to prefer feeding on these two cultivars.

All artificially inoculated plants died of bacteria1 wilt (string test used as described earlier) regardless of cultivar. All stem-inoculated plants were dead within 3 weeks, and all leaf-inoculated plants died within 5 weeks.

The relationship between the mean density of beetles observed on plants and the average feeding damage rating for each cultivar was strong ($P = 0.0003$, r = 0.91 ; Fig. 1, top). The same was true for the relationship between the average feeding damage rating and percentage of wilt ($P = 0.0001$, r = 0.9; Fig. 1, bottom). Correlation analysis supports the hypothesis that the more beetles on a plant, the greater the resultant feeding damage and the more likely the plant will become infected with the bacterium. 'Makdimon' and 'Rocky Sweet', and, to a lesser extent, 'Cordele' suffered greater amounts of feeding damage, which resulted in more infection with the bacterium and more bacterial wilt. Because all cultivars were equally susceptible to the disease once the

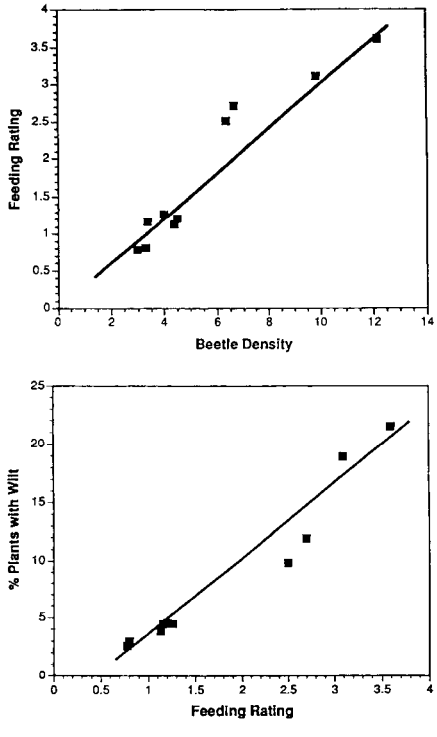

Fig. 1. **(a)** Relationship between beetle density (beetles/plant) in the field and feeding damage rating (on a scale from 0 = none to 5 = most severe) for 10 cultivars of muskmelon and **(b)** relationship between feeding damage rating in the field and the percentage of plants with bacterial wilt.

bacterium was introduced into the plant, striped cucumber beetle's feeding preference is probably most responsible for the high incidences of bacterial wilt in 'Makdimon' and 'Rocky Sweet'. The basis for this preference needs to be investigated.

Growers using these four cultivars will have to watch closely for the first evidence of beetle populations. It also may be possible to use 'Makdimon' or 'Rocky Sweet' as indicator plants on a small scale in the field to detect the first presence of large numbers of striped cucumber beetle.

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