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IMPROVED CONTROL OF CUCURBIT FOLIAR AND FRUIT DISEASES, OR HOW LESS FUNGICIDE IS BETTER IF PROPERLY APPLIED

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Background:

Control of foliar and fruit diseases of cucurbits is a difficult proposition given the extensive plant canopy and oft-hidden fruit that frequently require fungicide applications for protection. Providing adequate coverage has often been a difficult feature for growers to achieve. With our early attempt in 1991 to control powdery mildew of pumpkins in the field using bicarbonate sprays applied with a hand-held CO_2 sprayer, we quickly realized there had to be a better method of application if this mild, contact fungicide would have any chance for success in commercial agriculture. Early collaborative work with Richard C. Derksen of the Department of Agricultural and Biological Engineering at Cornell soon demonstrated that the use of an electrostatic sprayer would deliver the bicarbonate spray to foliage in a most effective manner. Other questions remained to be answered. How well would the electrostatic system perform under field conditions? Would better foliar disease control translate into better, disease-free fruit? Could we really demonstrate a difference in disease control between hydraulic and electrostatic sprayers? How well would conventional fungicides and bicarbonates perform when the two systems were compared? How could ultra-low volumes achieve the maximum coverage required? For the last two seasons we have compared the performance of a conventional hydraulic sprayer with an electrostatic sprayer using conventional fungicides and bicarbonates for the control of three diseases in cucurbits (powdery mildew, Septoria leaf and fruit spot, and gummy stem blight which in the fruit-infecting phase causes black rot). We chose butternut squash as the test crop because it has a dense plant canopy, it is highly susceptible to a number of foliar and fruit diseases, and it produces an adequate number of fruit to study postharvest disease development. The challenge was to control three diseases and produce marketable fruit. Results of our 1993 experiment are presented, but similar results were achieved in 1992 under even more intense disease pressure (1992, the summer without a summer).

Materials and Methods:

Our field plots were established at the Thompson Research Farm in Freeville, NY in an Eel silt loam soil which had previously been cropped to pumpkins in 1991, and butternut squash in 1992. This provided natural inoculum for Septoria leaf spot and gummy stem blight (black rot). We also relied upon natural powdery mildew inoculum which in the previous two seasons had shown insensitivity to the systemic fungicides Bayleton and Benlate. Butternut squash was direct-seeded on 7 Jun and later thinned to one plant/hill on 25 Jun. Rows were mulched with 4 ft wide x 1.25 mil black plastic (Poly Mulch). Individual plots consisted of single 15 ft rows with 8 plants spaced 2 ft apart in each row. Rows were spaced 14 ft apart to accommodate the tractor-mounted sprayers. The experimental design was a split plot using the two sprayers (hydraulic and electrostatic) with eight treatments (water plus 7 fungicide combinations), and three replications. The hydraulic sprayer delivered 27 gpa through seven Tee-Jet hollow cone nozzles (D 2-23) at 13 in. spacing and 200 psi. The electrostatic, inductive charging sprayer used 10 twin-fluid nozzles (air and water) and applied 4.5 gpa. Air pressure on the electrostatic sprayer was 30 psi and water pressure was 15 psi. Tractor speed was adjusted to achieve the desired application rate for each sprayer. Fungicide scheduling allowed for early season control of Septoria, followed by control of powdery mildew and black rot. Foliar rating for Septoria and mildew used the scale of: 0 = none; 1 = < 10% surface area affected; 2 = 11-25%; 3 = 26-45%; 4 = 46-60%; 5 = 61-80%; 6 = 81-100%. Septoria and black rot on fruit were rated as % surface area affected: 0 = none; 1 = 0.1 - 0.3; 2 = 0.4 - 0.6; 3 = 0.7 - 1.0; 4 = 1.1 - 2; 5 = 2.1 - 5, with unmarketable fruit considered at 3 and above. Precipitation was 4.93, 3.42, 3.45, and 3.89 in. for Jun, Jul, Aug, and Sep, respectively. Mean temperatures for the same months were 63, 69, 67, and 60° F, respectively. A damaging frost occurred on 20 Sep prior to fruit harvest on 22 Sep. Although undesirable, the frost actually proved to be fortuitous.

Results:

Rainfall was adequate and evenly distributed during the growing season and temperatures were near normal. Disease severity for Septoria and black rot was lower in 1993 than in 1992; nevertheless, sufficient disease occurred to give meaningful results. Septoria lesions appeared on the cotyledons and first true leaves on 6 Jul, and spread to the canopy during the period from 2-17 Aug. Septoria fruit lesions appeared on 24 Aug. Mildew was noted on 2 Aug and coincided with the onset of initial fruit set. Selection and scheduling of fungicides treatments allowed for good control of Septoria (see **Table**). The electrostatically-sprayed plots had consistently lower foliar disease ratings for Septoria and mildew, with all treatments providing good disease control. Similarly, better fruit disease control was noted when treatments were applied with the electrostatic sprayer. No Septoria fruit lesions appeared when the treatments were applied electrostatically. Black rot lesions were also generally lower for most treatments when compared with those applied with the hydraulic sprayer. Marketable yields (less disease) was significantly higher for treatments Bravo 825, Bravo 720 + Benlate 50W till fruit formation and then Bravo 720 and for Bravo 720 + Benlate 50W used full season. Frost damage was recorded on most fruit harvested from plots sprayed with either sprayer, but the severity of damage leading to black rot development in storage was greater across treatments sprayed hydraulically.

Conclusions:

Research results from the past two seasons have answered the questions posed in the introduction, and has added additional knowledge for the use of IPM principals for cucurbit disease control. Can three independently-functioning diseases be controlled using IPM scouting techniques? Yes Scouting for Septoria leaf spot allowed the timing of early season sprays to prevent fruit infection. Similarly, scouting indicated when sprays should begin for powdery mildew control. Growers should rotate out of cucurbits for at least two seasons to reduce the risk of soilborne inoculum which in these studies were Septoria and gummy stem blight (black rot). We intentionally did not rotate to increase disease pressure for our studies. Could we demonstrate a difference between electrostatic and hydraulic sprayers in terms of better foliage and fruit disease control and higher marketable yields? Yes, and significantly in most instances! When fungicides were applied electrostatically, less foliar Septoria leaf spot occurred and no Septoria fruit lesions developed. Despite resistance to Bayleton and Benlate for powdery mildew control, less mildew developed in electrostatically-sprayed plots. Better black rot control was achieved in plots sprayed electrostatically. Higher marketable yields and less frost damage leading to secondary breakdown in storage were noted for selected fungicide treatments applied electrostatically. How could a spray system (electrostatic) influence the amount of frost damage noted on fruit? Delivering the better fungicide treatments in the most effective manner contributed to a healthier plant canopy (less disease), less stress during fruit development and maturation, and thus a "sounder" fruit, better able to withstand frost injury.

Disclaimer:

Bravo 720, Benlate 50W, and Bayleton 50DF are currently registered for control of diseases of cucurbits. Bravo 825 WDG (wettable dry granules) will be available on a limited basis in 1994. Omni (ASC 66792) is an experimental product of ISK Biotech Corporation and will be marketed under a different trade name in the future. The formulation of potassium bicarbonate ($KHCO_3$) used in this study was provided by Uniroyal Chemical Co. Bicarbonates are not registered on any food crop and no recommendation is implied in this report.

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Table 1. Selection and scheduling of fungicide sprays using electrostatic (E) or standard (S) hydraulic sprayers and their effect on Septoria, powdery mildew, and black rot severity and butternut squash yield at Freeville, NY in 1993.

Treatment and rate/100 gal*	Foliar ratings: Septoria (17 Aug)	Foliar ratings: Mildew (24 Aug)	Fruit ratings (30 Sep): Septoria	Fruit ratings (30 Sep): Black rot	Marketable fruit yield (lb): (less disease)	Marketable fruit yield (lb): (frost damage)
Control (water) (E)	2.3 (2.3)**	3.5 (3.8) a	1.0 (1.3) a	0.9 (1.1) a	39.4 (30.6) b	11.0 (8.1) a
(S)	2.3	4.2	2.6	1.2	21.6	5.3
Bravo 720, 3 pt (A-H) (E)	0.4 (0.8)	2.3 (2.7) b	0.0 (0.2) b	0.4 (0.6) a	45.3 (43.3) ab	0.0 (4.2) a
(S)	1.2	3.0	0.5	0.8	41.2	8.4
Bravo 825, 2.7 lb (A-H) (E)	0.4 (0.5)	2.2 (2.4) b	0.0 (0.1) b	0.6 (0.6) a	44.2 (46.4) a	0.0 (2.6) a
(S)	0.6	2.7	0.3	0.6	48.4	5.3
Bravo 720, 3 pt + Benlate 50W, 0.5 lb (A) **then** Omni 4.25 pt (B,D,F,H) **alternate** Bravo 720, 3 pt (C,E,G), (E)	0.4 (0.6)	2.2 (2.7) b	0.0 (0.2) b	0.4 (0.8) a	44.9 (42.5) ab	2.2 (5.0) a
(S)	0.7	3.2	0.3	1.3	40.0	7.7
Bravo 720, 3 pt + Benlate 0.5 lb (A,B) **then** Bravo 720, 3 pt (C-H) (E)	0.2 (0.6)	2.3 (2.8) ab	0.0 (0.4)b	0.2 (0.8) a	44.7 (38.7) ab	4.6 (4.8) a
(S)	1.0	2.7	0.8	1.4	33.0	5.1
Bravo 720, 3 pt + Benlate 0.5 lb **till fruit** (A,B,C,D) **then** Bravo 720, 3 pt (E,F,G,H) (E)	0.2 (0.4)	2.0 (2.3) b	0.0 (0.2) b	0.5 (0.8) a	49.4 (48.2) a	4.6 (3.5) a
(S)	0.7	2.5	0.3	0.9	46.9	2.4
Bravo 720, 3 pt + Benlate 0.5 lb (A-H) (E)	0.2 (0.8)	1.8 (2.2) b	0.0 (0.2) b	0.4 (0.6) a	48.3 (46.4) a	0.0 (2.0) a
(S)	1.4	2.5	0.3	0.7	52.4	4.0
Benlate 0.5 lb + $KHCO_3$ 1% (A); Bayleton 50DF, 4 oz + Benlate + $KHCO_3$ (B); Bayleton + $KHCO_3$ (C,D); then Benlate + $KHCO_3$ (E,F,G,H) (E)	0.5 (0.7)	2.0 (2.4) b	0.0 (0.3) b	0.9 (0.8) a	44.4 (43.8) ab	9.5 (9.7) a
(S)	0.9	2.8	0.6	0.6	43.1	9.7

*Spray dates A = 21 Jul; B = 27 Jul; C = 23 Aug; E = 17 Aug; F = 26 Aug; G = 31 Aug; H = 7 Sep.

**Figures in parentheses are averages across the systems; means followed by the same letter are not significantly different from ea other (Tukey's test, $P = 0.05$).