CR-7659
0792

OSU Current Report

Cooperative Extension Service • Division of Agricultural Sciences and Natural Resources
Oklahoma State University

FUNGICIDE CONTROL OF WATERMELON ANTHRACNOSE

Charles Patterson
OSU Department of Plant Pathology

Quality control is an important aspect of watermelon pest management. Production of anthracnose-free fruit is essential for their acceptance at the wholesale market. It is equally important, however, to maintain foliage as a means of protecting melons from sunburn and to assure maximum levels of soluble fruit solids (sugar).

Bayleton, due to its long-term systemic disease control activity at relatively low rates, is recommended for management of watermelon anthracnose epidemics. Begin treatments on a preventative basis when weather conditions described in this report prevail. Apply at the rate of 4 oz/ac at 21-day intervals. Discontinue treatments during prolonged periods of dry weather or when overhead irrigation is no longer in use. Although Bravo 720 did not increase efficacy, it is considered beneficial to include 1 pt/ac (or the equivalent rate of an alternate chlorothalonil formulation) in the tank mix as a means of decreasing the potential for selecting Bayleton-resistant strains of *C. orbiculare*. The fungicide combination is registered, and both compounds may be applied up to 24 hours before harvest. Fungicide requirements may vary each year and are dependent on rainfall amounts and stage of crop development relative to occurrence of anthracnose. Fungicides are most effective when applied by ground-driven, tractor-mounted equipment.

Anthracnose, caused by *Colletotrichum orbiculare* is a common disease of watermelons throughout Oklahoma. During 1989, a statewide epidemic resulted in heavy crop losses. It remains to be one of the state's most economically important watermelon diseases.

Planting anthracnose-resistant watermelon cultivars was previously the most efficient means of controlling disease. Varieties that conferred resistance to *C. orbiculare* race 1 (i.e. cv. Sunsweet) and races 1 and 3 (i.e. cv. Allsweet), however, were observed in field plantings during 1989 to be highly susceptible to the disease. Samples of infected leaves and fruit from commonly grown open-pollinated, hybrid, and triploid (seedless) cultivars (including "yellow-meated" and "icebox" types) were received from watermelon production areas of Oklahoma and Texas, 1989 through 1991. *C. orbiculare* race 2 was cultured from about 60% of the infected tissues. The new pathogenic race seemingly is widespread and likely responsible for recent anthracnose epidemics in several watermelon production areas of the United States. Watermelon cultivars resistant to race 2 currently are not available. Fungicides have, therefore, become an important component in management of anthracnose epidemics. Effective disease control, however, is dependent on proper fungicide selection and timing of application relative to sources of *C. orbiculare* inoculum, anthracnose epidemiology, and the disease cycle. The purpose of this report is to provide the watermelon industry current recommendations for management of watermelon anthracnose.

Sources of Inoculum

Anthracnose is a seedborne disease. *C. orbiculare* can persist several months in stored seed. The pathogen commonly resides on the seed coat but occasionally infects internal tissues. Anthracnose contaminated seedlots sampled during 1989 to 1991 contained less than 1% infected seed, of which only about 5% actually transmitted the disease in greenhouse grow-out tests. Although transmission normally occurs at a low rate, it is a significant means of disease spread and dispersal of new *C. orbiculare* races. Seed transmission is an increasingly important problem in greenhouse production of transplants where environment, overhead irrigation, and plant density favor disease development and spread.

Several anthracnose fungicide seed treatments have been tested but were ineffective in eliminating the pathogen or suppressing transmission. Sodium hypochlorite (bleach) or formalin treatments administered by hot water methods decreased transmission, but also reduced seed viability 20 to 30%. Seed companies, therefore, are encouraged to produce and distribute only disease-free seed. Watermelon growers must use caution in purchasing seed and avoid "good deals." Do not plant infected transplants or transplants produced in greenhouses where anthracnose is a suspected problem. Plants that appear healthy may carry the disease but have not yet developed symptoms. Establishing watermelon plantings with infected transplants will surely result in an epidemic and significant crop loss.

In mild climates, *C. orbiculare* overwinters on several cucurbit weed hosts. Because vegetation is normally killed by winter frost and freezes, this method of persistence rarely, if ever, occurs in Oklahoma. A significant source of inoculum is volunteer watermelons infected by seedborne or soilborne inoculum from previous crop residues. The pathogen has been reported to occur in surface water and, therefore, may be present in ponds used for irrigation. Postharvest inoculation of melons can occur when fruit is washed in *C. orbiculare*-contaminated water during packing.

Anthracnose epidemics in Oklahoma commonly are associated with plantings in fields previously cropped to *C. orbiculare*-infected watermelons. Recent studies determined the primary source of inoculum was soilborne, and can persist in soil 3 to 5 years without a susceptible cucurbit host. Three- to four-year rotation with non-cucurbit crops decreased disease incidence. Control, however, was short-term due to infection of watermelons by wind-blown inoculum from alternate sources and subsequent re-infestation of soil with infected crop residue.

Epidemiology and Disease Cycle

Anthracnose can occur at any stage of plant growth. The disease is most common on foliage and fruit, but roots also are affected. Epidemic development seemingly is dependent on three to four consecutive days of frequent rainfall. Amounts of precipitation required to initiate an epidemic have not been fully resolved, but frequency and duration of overhead irrigation typically applied to watermelons apparently are insufficient to initiate an epidemic. Plants likely become infected by soilborne inoculum dispersed in splashing water. Symptoms are evident six days (foliage) to ten days (fruit) after inoculation. Pink masses of conidia are borne on new lesions and serve as inoculum for the secondary disease cycles. Inoculum can be carried by field workers, farm equipment, and the insect, *Pimelia* sp., but the primary means of dispersal is splashing water due to rain and/or overhead irrigation. Distance of dispersal is dependent on wind velocity; conidia may be disseminated three to five miles from the primary inoculum source. Lesions remain quiescent for several weeks when conditions do not favor sporulation, but conidia are produced following 24-hour exposure to 100% relative humidity. Periods of dry weather, therefore, impede epidemic development and spread.

Fungicide Tests

Fungicide comparison studies were established in cooperation with Lanier Farms, Inc., Weatherford, OK, during 1989 and 1990. Three tests were conducted each year. Experimental sites were selected in disease-free fields but near anthracnose-infected watermelon fields. Fungicides and rates included: 1) Bayleton 50 WP (2- and 4-oz/ac); 2) Bravo 720 (1.5- and 2-pt/ac); 3) Ridomil Bravo 81 W (2-lb/ac); and 4) Bayleton 50 WP + Bravo 720 (2-oz + 1-pt/ac, respectively and 4-oz + 1-pt/ac, respectively). Two application schedules were assessed: a) prior to disease development (preventative treatment) and 7-, 14-, and 21-day intervals thereafter; or b) one to three days after symptoms were evident and 7-, 14-, and 21-day intervals thereafter.

Additional fungicide tests were conducted in 1990 and 1991. Treatments included: 1) Bravo 720 (2 pt/ac); 2) Bayleton 50 WP + Bravo 720 (4 oz + 1 pt/ac, respectively); and 3) Bayleton 50 DF + Bravo 720 (4 oz + 1 pt/ac, respectively). Treatments were applied by calendar-based (timed) methods: Bravo 720 at 7-day intervals and Bayleton at 21-day intervals; or weather-based methods 12 to 24 hours prior to predicted rainfall; Bravo 720 treatments did not exceed 1 application/7-day interim, and Bayleton treatments did not exceed 1 application/21-day interim.

Fungicides were applied in 20 gal of water/acre at 60 PSI pressure. Triton B 1956, a surfactant and spreader-sticker, was included in Bayleton and Ridomil/Bravo 81W treatments at a rate of 4 oz/ac. A tractor mounted, pesticide application unit equipped with four

fan tips, 8002 nozzles/watermelon row, was employed to evenly distribute fungicides over the foliar canopy. Treatment plots consisted of four watermelon rows replicated four times in a completely random design; the area treated was 1.2 to 1.5 acres, depending on field length. A non-treated control was included in each replicate.

Experimental blocks were evaluated for anthracnose at each of three consecutive watermelon harvests. Disease indices assessed included incidence (percent leaves infected by *C. orbiculare*) and severity (number of lesions/ infected leaf); data were recorded as anthracnose intensity, a factor of incidence X severity. Yield loss due to anthracnose was recorded as percent fruit infected by *C. orbiculare*. Data were tested by statistical analysis to identify sources of variance and significant differences in treatment means.

Results and Discussion

These studies provided data pertinent to selection of fungicides for effective and economically efficient management of watermelon anthracnose epidemics. Fungicide specificity, mode of action, application rate, and residual disease control activity all are factors to consider in the disease control decision process. In addition, disease epidemiology in relation to weather are important in timing of fungicide application and fungicide requirements for effective anthracnose control.

Bayleton was the most effective fungicide for control of watermelon anthracnose; addition of Bravo 720 to the tank mix did not enhance efficacy. Maximum disease protection and highest yields were attained by preventative treatments of 4 oz/ac applied at 7-, 14-, or 21-day intervals (Tables I and II). Application schedules did not significantly differ; Bayleton treatments at 21-day intervals, therefore, resulted in excellent anthracnose control. Efficacy decreased when preventative treatments were reduced to 2 oz/ac, and treatments at 7- or 14-day intervals were required to provide acceptable disease control. The fungicide was less effective when treatments were initiated after disease development. Consequently, minimum levels to reduce anthracnose intensity and crop loss were 2 oz/ac at 7-day intervals or 4 oz/ac at 14-day intervals.

Bravo 720 significantly reduced anthracnose intensity when treatments were initiated prior to disease development and applied at 2 pt/ac in 7-day intervals. The fungicide, however, did not reduce crop loss. Ridomil/Bravo 81W did not differ from untreated plots and, therefore, was ineffective.

Studies that compared calendar-based and weather-based treatment methods confirmed efficacy results from previous fungicide tests (Tables III and IV). They also determined there were no differences between Bayleton 50 WP or 50 DF formulations. In addition, weather-based fungicide applications were equally effective compared to calendar-based treatments. Fungicide requirements were, therefore, dependent on rainfall, and applications during extended periods of dry weather did not increase anthracnose control. Thus, weather-based methods of disease control significantly reduced fungicide requirements, provided an "environmentally friendly" approach to disease control, and decreased the potential for development of Bayleton resistant strains of *C. orbiculare*.

Bayleton is a systemic triazol compound, selective in controlling certain diseases incited by specific fungi, and effective at very low rates. These results and supplemental greenhouse tests indicated residual disease control activity of 14 (2 oz/ac) to 21 (4 oz/ac) days. This is beneficial during periods of frequent rainfall that prohibit tractor equipment from entering fields and eliminates pesticide applications that may interfere with harvest operations. Bravo 720 (and other chlorothalonil formulations) is a broad-spectrum contact fungicide that dissipates due to rain or overhead irrigation; therefore, control is short-term. Primary registration of Ridomil/Bravo 81W is intended for control of downy mildew and related watermelon diseases, but anthracnose is included on the fungicide label. The amount of Bravo contained in the formulation, however, is insufficient for anthracnose control.

NOTE: Always follow label regulations when applying fungicides or any pest control agent.

TABLE I. FUNGICIDE EFFICACY FOR ANTHRACNOSE CONTROL ON WATERMELON CULTIVAR ALLSWEET (1989)

TREATMENT	RATE/AC	INITIAL TREATMENT PRE	INITIAL TREATMENT POST	APPLICATION INTERVALS 7	APPLICATION INTERVALS 14	APPLICATION INTERVALS 21	TOTAL NUMBER OF TREATMENTS	% INFECTED AI	% INFECTED FRUIT
BAYLETON 50 WP	2 oz	X		X			10	37.9	28.4
"	"	X			X		6	46.1	39.3
"	"	X				X	4	53.6	48.2
"	"		X	X			10	48.7	39.9
"	"		X		X		6	54.6	46.7
"	"		X			X	4	61.8	49.6
"	4 oz	X		X			10	12.3	4.8
"	"	X			X		6	11.9	5.1
"	"	X				X	4	13.2	5.5
"	"		X	X			10	21.4	11.6
"	"		X		X		6	20.2	12.1
"	"		X			X	4	32.7	21.9
BRAVO 720	1.5 pt	X		X			10	70.8	59.0
"	"	X			X		6	70.1	60.2
"	"	X				X	4	72.9	58.6
"	"		X	X			10	73.8	57.7
"	"		X		X		6	73.2	59.3
"	"		X			X	4	72.5	61.4
"	2 pt	X		X			10	54.3	55.0
"	"	X			X		6	69.1	59.9
"	"	X				X	4	67.6	61.8
"	"		X	X			10	70.4	59.0
"	"		X		X		6	73.9	60.7
"	"		X			X	4	72.7	60.2
RIDOMIL/ BRAVO 81W	.2 lb	X		X			10	69.3	56.0
"	"	X			X		6	68.1	58.3
"	"	X				X	4	70.6	60.0
"	"		X	X			10	71.3	61.1
"	"		X		X		6	72.1	59.7
"	"		X			X	4	68.3	60.4
BAYLETON 50WP + BRAVO 720	2 oz + 1 pt	X		X			10	39.6	17.9
"	"	X			X		6	44.2	18.2
"	"	X				X	4	48.0	21.3
"	"		X	X			10	48.7	25.5
"	"		X		X		6	54.2	26.8
"	"		X			X	4	60.9	28.4
"	4 oz + 1 pt	X		X			10	13.1	6.3
"	"	X			X		6	12.8	7.1
"	"	X				X	4	13.6	5.9
"	"		X	X			10	22.1	22.2
"	"		X		X		6	32.4	22.8
"	"		X			X	4	29.5	21.9
CONTROL								74.4	59.7

- Fungicides were applied in 20 gal of water/ac.
- Initial Treatments: Pre = preventative; applied prior to symptom development. Post = applied 24 - 72 hr following symptom development.
- Application intervals: days after initial treatment.
- AI: Anthracnose intensity (% infected leaves X mean lesions/infected leaf). Greatest mean level AI/leaf to result in defoliation = 75. Determined at each of 3 intervals corresponding to harvest; represents maximum level of AI recorded during final assessment. Figures within the column are mean values of 3 tests and 4 treatment replicates. PLSD (0.05) = 16.93; significant difference between treatment means.
- % Infected fruit: determined at each of 3 harvest intervals; represents total loss due to anthracnose. Figures within the column are mean values of 3 tests and 4 treatment replicates. PLSD (0.05) = 10.78; significant difference between treatment means.

TABLE II. FUNGICIDE EFFICACY FOR ANTHRACNOSE CONTROL ON WATERMELON CULTIVAR ALL SWEET (1990)

TREATMENT	RATE/AC	INITIAL TREATMENT PRE	INITIAL TREATMENT POST	APPLICATION INTERVALS 7	APPLICATION INTERVALS 14	APPLICATION INTERVALS 21	TOTAL NUMBER OF TREATMENTS	% INFECTED AI	% INFECTED FRUIT
BAYLETON 50 WP	2 oz	X		X			7	15.9	11.8
"	"	X			X		4	15.3	12.6
"	"	X				X	3	15.7	11.9
"	"		X	X			7	16.6	14.3
"	"		X		X		4	15.9	14.8
"	"		X			X	3	16.5	15.7
"	4 oz	X		X			7	2.9	2.7
"	"	X			X		4	3.3	2.9
"	"	X				X	3	3.6	3.1
"	"		X	X			7	15.6	9.9
"	"		X		X		4	14.7	9.5
"	"		X			X	3	15.3	9.6
BRAVO 720	1.5 pt	X		X			7	54.9	25.8
"	"	X			X		4	51.7	24.6
"	"	X				X	3	52.8	26.5
"	"		X	X			7	53.9	23.4
"	"		X		X		4	50.2	24.0
"	"		X			X	3	51.4	25.8
"	2 pt	X		X			7	39.6	23.1
"	"	X			X		4	49.8	23.7
"	"	X				X	3	48.0	22.9
"	"		X	X			7	51.1	24.8
"	"		X		X		4	52.6	25.1
"	"		X			X	3	54.2	23.8
RIDOMIL/ BRAVO 81W	2 lb	X		X			7	51.3	24.9
"	"	X			X		4	52.0	25.1
"	"	X				X	3	52.7	23.0
"	"		X	X			7	53.6	25.9
"	"		X		X		4	49.0	24.3
"	"		X			X	3	49.5	24.8
BAYLETON 50WP + 2 oz + BRAVO 720	1 pt	X		X			7	51.6	26.2
"	"	X			X		4	16.1	10.5
"	"	X				X	3	15.9	10.7
"	"		X	X			7	22.2	16.1
"	"		X		X		4	24.8	14.7
"	"		X			X	3	25.3	15.4
"	4 oz + 1 pt	X		X			7	2.8	2.9
"	"	X			X		4	3.1	3.2
"	"	X				X	3	3.6	2.8
"	"		X	X			7	12.8	8.1
"	"		X		X		4	13.1	7.9
"	"		X			X	3	14.2	9.5
CONTROL								53.7	25.2

- Fungicides were applied in 20 gal of water/ac.
- Initial Treatments: Pre = preventative; applied prior to symptom development. Post = applied 24 - 72 hr following symptom development.
- Application intervals: days after initial treatment.
- AI: Anthracnose intensity (% infected leaves X mean lesions/infected leaf). Greatest mean level AI/leaf to result in defoliation = 75. Determined at each of 3 intervals corresponding to harvest; represents maximum level of AI recorded during the final assessment interim. Figures within the column are mean values of 3 tests and 4 treatment replicates. PLSD (0.05) = 8.71; significant difference between treatment means.
- % Infected fruit: determined at each of 3 harvest intervals; represents total loss due to anthracnose. Figures within the column are mean values of 3 tests and 4 treatment replicates. PLSD (0.05) = 6.93; significant difference between treatment means.

TABLE III. DIFFERENCES BETWEEN CALENDAR-BASED AND WEATHER-BASED FUNGICIDE APPLICATION SCHEDULES FOR ANTHRACNOSE CONTROL ON WATERMELON CV. ALLSWEET (1990)

TREATMENT	RATE/ ACRE	APPLICATION SCHEDULE C-B	W-B	TOTAL NUMBER OF TREATMENTS	AI	% INFECTED FRUIT
BAYLETON 50WP + BRAVO 720	4 oz + 1 pt	X		5	4.8	7.7
"	"		X	2	5.2	7.4
BAYLETON 50DF + BRAVO 720	4 oz + 1 pt	X		5	5.6	6.9
"	"		X	2	4.9	7.1
BRAVO 720	2 pt	X		12	31.3	27.1
"	"		X	7	35.8	26.0
CONTROL	"				58.6	27.3

- Summary of 2 tests.
- Treatments were applied in 20 gal of water/ac. Bayleton treatments included Triton B 1956 spreader/sticker at a rate of 4 oz/ac.
- Treatments were initiated when weather conditions favorable for disease development prevailed. Application schedule: C-B = calendar-based; W-B = weather-based. C-B Bayleton treatments were applied at 21-day intervals; W-B Bayleton treatments were applied 24 - 48 hr prior to predicted rainfall but did not exceed 1 application/21 day interim. C-B Bravo 720 treatments were applied at 7-day intervals; W-B Bravo 720 treatments were applied prior to predicted rainfall but did not exceed 1 application/7 day interim.
- W-B treatment schedules significantly reduced application requirements for disease control.
- AI = Anthracnose intensity. Assessed at each of 3 intervals corresponding to harvest. Figures within the column represent AI measured during the final assessment interval and are mean values of 4 replications. PLSD (0.05) = 17.92 (significant difference between treatment means).
- % infected fruit: determined at each of 3 harvest intervals; represents total loss due to anthracnose. Figures within the column are mean values of 2 tests and 4 treatment replicates. PLSD(0.05) = 15.43 (significant difference between treatment means).

TABLE IV. DIFFERENCES BETWEEN CALENDAR-BASED AND WEATHER-BASED FUNGICIDE APPLICATION SCHEDULES FOR ANTHRACNOSE CONTROL ON WATERMELON CV. ALLSWEET (1991)

TREATMENT	RATE/ ACRE	APPLICATION SCHEDULE C-B	W-B	TOTAL NUMBER OF TREATMENTS	AI	% INFECTED FRUIT
BAYLETON 50WP + BRAVO 720	4 oz + 1 pt	X		4	3.6	5.9
"	"		X	2	3.8	5.2
BAYLETON 50DF + BRAVO 720	4 oz + 1 pt	X		5	4.1	5.5
"	"		X	2	3.2	5.7
BRAVO 720	2 pt	X		10	19.8	18.1
"	"		X	4	21.4	19.6
CONTROL	"				39.5	21.8

- Results of 1 test.
- Treatments were applied in 20 gal of water/ac. Bayleton treatments included Triton B 1956 spreader/sticker at a rate of 4 oz/ac.
- Treatments were initiated when weather conditions favorable for disease development prevailed. Application schedule: C-B = calendar-based; W-B = weather-based. C-B Bayleton treatments were applied at 21-day intervals; W-B Bayleton treatments were applied 24 - 48 hr prior to predicted rainfall but did not exceed 1 application/21 day interim. C-B Bravo 720 treatments were applied at 7-day intervals; W-B Bravo 720 treatments were applied prior to predicted rainfall but did not exceed 1 application/7 day interim.
- W-B treatment schedules significantly reduced application requirements for disease control.
- AI = Anthracnose intensity. Assessed at each of 3 intervals corresponding to harvest. Figures within the column represent AI measured during the final assessment interval and are mean values of 4 replications. PLSD (0.05) = 11.34 (significant difference between treatment means).
- % infected fruit: determined at each of 3 harvest intervals; represents total loss due to anthracnose. Figures within the column are mean values of 2 tests and 4 treatment replicates. PLSD(0.05) = 10.47 (significant difference between treatment means).

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