Efficacy of Dicarboximide Fungicides and Fungicide Combinations for Control of Botrytis Leaf Blight of Onion in New York

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ABSTRACT

Lorbeer, J. W., and Vincelli, P. C. 1990. Efficacy of dicarboximide fungicides and fungicide combinations for control of Botrytis leaf blight of onion in New York. Plant Dis. 74:235-237.

Iprodione and vinclozolin provided partial control of Botrytis leaf blight of onion when used alone at moderate to high rates (1.12–2.24 kg/ha). Disease control achieved with the dicarboximide fungicides was improved when they were mixed with other protectant fungicides, even at rates of the dicarboximide fungicides as low as 0.56 kg/ha. Excellent disease control was obtained by mixing iprodione (0.56 kg/ha) and chlorothalonil (0.58–0.87 kg/ha) with either maneb + zinc (2.69 kg/ha) or mancozeb (1.79 kg/ha). Use of these mixtures would improve the cost-effectiveness of iprodione and vinclozolin and reduce the potential for development of *Botrytis squamosa* populations resistant to these fungicides.

Botrytis leaf blight, caused by *Botrytis squamosa* J. C. Walker, is one of the most important diseases of onion (*Allium cepa* L.) in New York. Although sanitation practices that reduce primary inoculum can contribute to disease control (3), the principal means of controlling this disease is by applying protectant fungicides on a regular basis from about mid-June until late August (6,8,11,12).

Although certain ethylene bisdithiocarbamate (EBDC) fungicides are currently registered for control of Botrytis leaf blight, there are shortcomings associated with their use. The efficacy of the EBDC fungicides in controlling this disease in New York declined dramatically between 1969 and 1972 (7). Exclusive use of these fungicides has continued to give less-than-adequate disease control. The reason for this decline in efficacy has not been firmly established. Chlorothalonil is effective in controlling the disease and is currently a standard fungicide for the industry. As part of an ongoing effort to identify new fungicides for control of Botrytis leaf blight of onion, the dicarboximide fungicides iprodione and vinclozolin were evaluated in field trials, both alone and in combination with other protectant fungicides. This paper presents the results of those investigations.

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Accepted for publication 6 September 1989.

MATERIALS AND METHODS

Iprodione (Rovral 50WP) and vinclozolin (Ronilan 50WP) were evaluated for efficacy in controlling Botrytis leaf blight in fungicide trials at commercial onion fields in Orange County, New York, during 1984–1986. The fungicides were tested at various rates alone and in combination with mancozeb (Dithane M-45 80WP), maneb + zinc (Dithane FZ 4F), and/or chlorothalonil (Bravo 500 4.17F). The procedures followed in these experiments have been outlined previously (6). Four-row plots measuring 1.52 × 6.63 m were arranged in a randomized complete-block design. Fungicide sprays were applied weekly (unless otherwise noted) using a CO_2-pressurized, hand-held sprayer fitted with Teejet 8002 nozzles and delivering 65.3 L of water per hectare. Leaf greenness ratings (LGR) were taken in each trial on the dates indicated using a scale ranging from 0 (no leaf greenness) to 10 (full leaf greenness). Two independent ratings were averaged for each plot. Because Botrytis leaf blight was the principal cause of leaf necrosis in these trials (no other foliar diseases were detected), we converted LGRs to leaf blight ratings (LBRs) as follows: LBR = −1 (LGR −10). The LBR scale rates the relative amount of foliar disease on a scale ranging from 0 (plants essentially disease-free) to 10 (plants completely blighted). Yields were determined by harvesting and weighing bulbs from 5.49 m in the middle of the center two rows of each plot on the dates indicated.

In 1984, the cultivar Spartan Banner was planted 20 April, and foliar sprays

were applied nine times on a weekly basis beginning 21 June. In 1985, the cultivar Sentinel was planted 2 April, and sprays were applied eight times on a weekly basis beginning 18 June. In 1986, Sentinel was planted 9 April, and sprays were applied eight times on a weekly basis beginning 24 June.

Although a variety of fungicide treatments were tested each year, data are presented only for treatments that included dicarboximide fungicides and for appropriate control treatments. However, results of Duncan's multiple range tests ($P = 0.05$) performed on each complete experiment are presented here to maintain the degree of statistical precision achieved in each experiment.

Disease development in all 3 yr was moderate to severe, permitting adequate evaluation of the efficacies of the different fungicide treatments. We kept a count of leaf wetness episodes (LWEs) lasting 12 hr or longer (needed for onion leaf infection by *B. squamosa*) that occurred between 15 June and 15 August of each year. These episodes were monitored as described previously (16).

Table 1. Efficacies of iprodione and vinclozolin used alone and in combination with chlorothalonil and/or maneb + zinc and of a chlorothalonil and maneb + zinc mixture for control of Botrytis leaf blight of onion in 1984

Fungicide	Rate (kg/ha)	Leaf blight rating[x,y]	Bulb yield (kg/plot)[y]
Iprodione[z]	1.12	1.5 ab	27.0 ab
Iprodione[z]	2.24	1.4 a	25.7 abc
Vinclozolin[z]	1.12	4.6 e	25.7 abc
Vinclozolin[z]	2.24	3.4 d	26.0 ab
Vinclozolin + chlorothalonil	1.12 0.87	3.0 d	26.1 ab
Vinclozolin + chlorothalonil	2.24 0.87	2.1 bc	23.1 bc
Vinclozolin + maneb + zinc	0.56 2.69	4.4 e	27.8 a
Vinclozolin + maneb + zinc	1.12 1.79	4.6 e	27.2 ab
Vinclozolin + maneb + zinc	1.68 0.90	4.1 e	26.7 ab
Vinclozolin + chlorothalonil + maneb + zinc	0.84 0.87 1.79	2.8 cd	25.8 ab
Chlorothalonil + maneb + zinc	0.84 1.79	4.1 e	25.4 abc
No fungicide	···	7.5 f	21.6 c

[x] A 0–10 scale ranging from 0 (plants essentially disease-free) to 10 (plants completely blighted). Ratings made on 13 August 1984.
[y] Means in a column followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test. Yields determined on 27 August 1984.
[z] Triton B-1956 included at 443 ml/ha. Triton B-1956 was used with WP formulations. It was not used when WP formulations were combined with flowable formulations.

Table 2. Efficacies of iprodione, vinclozolin, and chlorothalonil used alone and of iprodione or vinclozolin in two-way combinations with maneb + zinc and in three-way combinations with chlorothalonil and maneb + zinc for control of Botrytis leaf blight of onion in 1985

Fungicide	Rate (kg/ha)	Leaf blight rating[x,y]	Bulb yield (kg/plot)[y]
Iprodione[z]	0.84	3.2 bc	29.6 a
Vinclozolin[z]	1.12	3.3 bc	28.9 a
Chlorothalonil	1.16	3.8 cd	28.1 a
Maneb + zinc	2.69	5.1 d	28.3 a
Iprodione + maneb + zinc	0.56 2.69	1.9 a	30.1 a
Vinclozolin + maneb + zinc	0.56 2.69	2.7 abc	30.1 a
Iprodione + chlorothalonil + maneb + zinc	0.56 0.87 2.69	1.7 a	28.4 a
Vinclozolin + chlorothalonil + maneb + zinc	0.56 0.87 2.69	2.4 ab	29.6 a
No fungicide	···	6.1 e	23.9 b

[x] A 0–10 scale ranging from 0 (plants essentially disease-free) to 10 (plants completely blighted). Ratings made on 7 August 1985.
[y] Means in a column followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test. Yields determined on 20 September 1985.
[z] Triton B-1956 included at 443 ml/ha. Triton B-1956 was used with WP formulations. It was not used when WP formulations were combined with flowable formulations.

Disease pressure was moderate in 1984, with 25 LWEs of 12 hr or longer recorded. Disease pressure in 1985 was severe. Disease developed early, and 28 LWEs lasting 12 hr or longer were recorded. In 1986, disease pressure was moderate. Botrytis leaf blight was not observed until midseason, after which numerous periods of rainfall occurred; 22 LWEs of 12 hr or longer were recorded.

RESULTS

Iprodione and vinclozolin provided varying levels of control of Botrytis leaf blight of onion in experiments conducted during 1984–1986 (Tables 1–3). In two of the three experiments, iprodione used alone provided better control of Botrytis leaf blight than vinclozolin used alone, as measured by LBRs (Tables 1 and 3). The two fungicides used alone provided equal levels of control in the third test, although iprodione was used at a lower rate than vinclozolin (Table 2). While both provided partial disease control when used alone at 0.84 kg/ha, neither provided the desired level of disease control at this low rate (Table 3).

Although iprodione at 0.84 kg/ha provided only partial control of Botrytis leaf blight, disease control was significantly improved when iprodione was mixed at a lower rate (0.56 kg/ha) with maneb + zinc (Table 2), with chlorothalonil and maneb + zinc (Table 2), or with chlorothalonil and mancozeb (Table 3). In one of the three trials, the combination of vinclozolin with maneb + zinc significantly improved disease control over vinclozolin used alone (Table 3). No significant improvement was noted in the two trials in which the mixture of vinclozolin and maneb + zinc was tested. In two of three trials, a combination of vinclozolin at low rates (0.56–0.84 kg/ha) with chlorothalonil and a dithiocarbamate fungicide gave disease control superior to that obtained by using vinclozolin alone at low to moderate rates (0.84–1.12 kg/ha) (Tables 1 and 3). Exclusive use of maneb plus zinc (Table 2) or mancozeb alone (Table 3) gave poor control of Botrytis leaf blight.

DISCUSSION

Although some degree of disease control was achieved when the dicarboximide fungicides were used alone, control improved when these fungicides were mixed with other protectant fungicides. In our experiments, iprodione used alone controlled leaf blight significantly better than vinclozolin used alone. However, the efficacy of each fungicide was improved significantly when mixed with an EBDC fungicide and/or chlorothalonil. In particular, the combination of iprodione and an EBDC fungicide controlled Botrytis leaf blight better than chlorothalonil used alone or combined with an EBDC fungicide—the standard

Table 3. Efficacies of iprodione, vinclozolin, and mancozeb used alone, a vinclozolin and chlorothalonil mixture, iprodione or vinclozolin used in two-way combinations with maneb + zinc and in three-way combinations with chlorothalonil and mancozeb, and of a chlorothalonil and mancozeb mixture for control of Botrytis leaf blight of onion in 1986

Fungicide	Rate (kg/ha)	Leaf blight rating[x,y]	Bulb yield (kg/plot)[y]
Iprodione[z]	0.84	2.5 bc	19.7 bc
Vinclozolin[z]	0.84	4.3 de	20.0 bc
Mancozeb[z]	2.69	5.2 e	20.0 bc
Vinclozolin	0.56		
+ chlorothalonil	1.16	2.8 c	18.6 c
Iprodione	0.56		
+ maneb + zinc	2.69	1.7 ab	21.7 ab
Vinclozolin	0.56		
+ maneb + zinc	2.69	2.7 bc	23.1 a
Iprodione	0.56		
+ chlorothalonil	0.58		
+ mancozeb	1.79	1.4 a	20.3 bc
Vinclozolin	0.56		
+ chlorothalonil	0.58		
+ mancozeb	1.79	2.9 c	19.6 bc
Chlorothalonil	1.16		
+ mancozeb	1.79	2.4 bc	19.8 bc
No fungicide	...	6.2 f	19.1 bc

[x] A 0–10 scale ranging from 0 (plants essentially disease-free) to 10 (plants completely blighted). Ratings were made on 18 August 1986.

[y] Means in a column followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test. Yields determined on 20 August 1986.

[z] Triton B-1956 included at 443 ml/ha. Triton B-1956 was used with WP formulations. It was not used when WP formulations were combined with flowable formulations.

foliar fungicide treatments for the New York onion industry in recent years.

In two of three trials in which a mixture of vinclozolin and maneb + zinc was tested, use of the mixture resulted in significantly less disease control (as measured by LBRs) than use of the best-performing fungicide treatment in those trials. However, treatment with this mixture always resulted in bulb yields that were among the highest for the different treatments. Confirming previous findings (7), our results indicate that continued application of the EBDC fungicides alone leads to poor control of Botrytis leaf blight of onion in the Orange County area of New York.

The improvement in efficacy after adding one or two protectant fungicides to an iprodione or vinclozolin spray was especially evident with iprodione. In all experiments in which such mixtures were tested, the best disease control was achieved by mixing iprodione with chlorothalonil and an EBDC fungicide. Efficacious mixtures of dicarboximide fungicides at low rates (<1 kg/ha) and other protectant fungicides would improve the cost-effectiveness of the relatively expensive dicarboximide compounds. Cost-effectiveness could be further improved by postponing use of dicarboximide compounds in a spray program until disease increases to an action threshold (13,15).

In addition to providing good disease control, the use of the dicarboximide fungicides in combination with other protectant fungicides should help delay the development of dicarboximide-resistant populations of *B. squamosa* (2,4,5,14). Resistance to dicarboximide fungicides has been reported in *Botrytis* spp. (1,9), including resistance in *B. squamosa* to iprodione induced in vitro (10). Although resistance to dicarboximide fungicides has not been observed in *B. squamosa* in the United States, the potential for development of resistance may exist. Accordingly, the wisest use of the dicarboximide fungicides would be in combination with other protectant fungicides to delay the buildup of such resistance.

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