Control of Bottom Rot of Head Lettuce with Iprodione

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ABSTRACT

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Bottom rot of lettuce (caused by *Rhizoctonia solani*) commonly results in serious losses in Wisconsin because of a lack of effective, economical control measures. Field tests were conducted in 1982 and 1983 in commercial lettuce plantings to determine the efficacy of iprodione and other fungicides. Iprodione increased yield as much as 92% and decreased disease severity compared with untreated controls. Two applications with 2.3 kg/ha of an iprodione 50WP formulation directed at the bases of plants and over leaves 4 and 6 wk after seeding gave adequate control under most conditions. Iprodione was registered for use on commercial head lettuce in 1983.

Additional key words: *Lactuca sativa*

Bottom rot of lettuce (*Lactuca sativa* L.) caused by the soilborne fungus *Rhizoctonia solani* Kühn can be a serious problem, especially during warm, wet seasons. Infected plants must be trimmed in the field to remove affected leaves before packing or left unharvested, depending on the severity of infection. Losses as great as 70% can occur when conditions favor disease development (3).

The disease is most commonly a problem on lettuce plants that have headed and are nearly mature, but rust-colored lesions can occur on lower leaves in contact with the soil as early as 4 wk after direct seeding. Under moist conditions, *R. solani* lesions also provide an entrance for soft-rot bacteria, which produce a rapid, dark-colored, slimy decay of the head (4).

Since the description of the disease in 1900 (7), many control methods have been attempted, including raised beds, crop refuse removal, fungicide treatments, and soil fumigation (1–3,8), but only with moderate success. For many years, lettuce growers in Wisconsin were unable to achieve effective, economical control of this disease. We collected preliminary data during 1981 that indicated a high potential for controlling bottom rot with directed foliar applications of iprodione (Rovral 50WP), a new fungicide then being introduced and marketed in the United States. This paper presents the results of additional field studies in 1982 and 1983 on the use of iprodione for reducing bottom rot of lettuce grown on organic soils in Wisconsin.

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MATERIALS AND METHODS

To determine the efficacy of iprodione compared with other fungicides, field tests were conducted in 1982 and 1983 in commercial fields where bottom rot had occurred in previous years. Soil type was a Houghton muck with pH 5.4–6.6. A randomized complete block design with three replicates was used in each field test. Each treatment replicate consisted of four beds with two 15.2-m-long lettuce rows per bed. Plots were direct-seeded with the cultivar Montello in two rows 0.3 m apart on 0.46-m-wide beds. Beds were spaced at 0.91-m intervals. Plantings were thinned 2 wk after direct seeding so that plants were spaced 0.3 m apart in the row. Pest management practices recommended by state specialists (6) were used in all field trials.

Fungicides were mixed in water and applied at 663 L/ha and 100 psi with a tractor-mounted boom sprayer. The sprayer was equipped with four Tee-Jet D4-45 disc-type cone nozzles per bed mounted on drop pipes and swivels. Nozzle placement was adjusted during the growing season to account for changes in plant height and to facilitate the accurate delivery of fungicide to the bases of plants. The sprayer boom was mounted on swivels and guided by rubber flotation tires that tracked in the troughs between beds; thus small changes in bed orientation resulted in identical changes in boom orientation. Only the bases of plants and lower leaves were sprayed directly with fungicide. Developing lettuce heads and upper leaf surfaces were exposed to minimal amounts of fungicide.

At harvest, lettuce was hand-picked by a commercial harvesting crew and individual heads were rated as they were cut. A rating scale of 0–3 was used, where 0 = no infection; 1 = plant infected, but affected leaves were removed with minimal trimming; 2 = moderate infection of wrapper leaves, but infection did not extend into trimmed head; and 3 = infection extended into trimmed head, head discarded. About 100–150 heads were rated at random for each treatment replicate in each trial. A disease index was calculated for each plot by the following formula: disease index = [sum of (disease class × number of heads in class) × 100]/total number of harvested heads × 3. Yields per hectare were calculated on the basis of 24 marketable lettuce heads per case.

1982 Trials. Field plots were established at a commercial lettuce farm near Berlin, WI, on two planting dates, 16 May and 10 July. Plots were fertilized with 0-0-60 NPK at 91 and 145 kg/ha preplant broadcast, 10-34-0 NPK at 312 and 426 L/ha banded at planting, and nitrogen at 68 and 45 kg/ha sidedressed 4.5 and 5.5 wk after planting, respectively.

Experimental fungicide treatments consisted of benomyl (Benlate 50WP) at 1.7 kg/ha, vinclozolin (Ronalin 50WP) at 2.3 kg/ha, propiconazole (Tilt 3.6E) at 0.3 and 0.6 L/ha, and iprodione 50WP at 1.7 and 2.3 kg/ha, each applied to both plantings in the fourth and sixth weeks after seeding. In addition to these treatments, propiconazole 3.6E at 0.3 and 0.6 L/ha was applied in the fourth week only and iprodione 50WP at 2.3 kg/ha was applied to the second planting in the fourth, fifth, and sixth weeks after seeding on the second planting.

1983 Trials. Fields plots were established at a commercial lettuce farm near Waupun, WI, on two planting dates, 25 May and 20 July. Both plots were fertilized with 0-0-60 NPK at 284 kg/ha preplant broadcast, 10-34-0 NPK at 379 L/ha banded at planting, and liquid nitrogen at 23 kg/ha sidedressed 4 wk after planting.

Fungicide treatments consisted of propiconazole 3.6E at 0.3 and 0.6 L/ha applied in the fourth week after seeding and vinclozolin 4F at 2.4 L/ha, propiconazole 3.6E at 0.3 L/ha, and iprodione 50WP at 2.3 kg/ha, each applied in the fourth and sixth weeks after seeding and iprodione 50WP at 2.3 kg/ha applied in the second, fourth, and sixth weeks after seeding.

Commercial use. The results of preliminary field tests led to the registration of iprodione with the Environmental Protection Agency for use on commercial lettuce in Wisconsin in 1982 and 1983 on an emergency exemption basis. To determine whether efficacy in small test plots and commercial acreages was comparable, iprodione 50WP was evaluated in commercial lettuce plantings at 2.3 kg/ha in the fourth and sixth weeks after seeding. Control plots were left untreated on lettuce farms near Berlin, WI (10 plots), in 1982 and near Coloma, WI (five plots), in 1983. Untreated areas consisted of 12 adjacent 15.2-m-long beds selected at random at about weekly intervals throughout the growing season. At harvest, plants from the four center beds of untreated areas and plants from adjacent treated beds were sampled at random and compared for disease incidence and severity and for marketable yield.

Plant infection. During 1982, samples of 10 plants each were removed at weekly intervals from untreated plots in commercial iprodione-treated lettuce plantings beginning 4 wk after seeding through harvest to determine the time of plant infection by *R. solani*. Tissue samples were surface-sterilized for 1 min in 70% EtOH, rinsed three times in sterile water, and plated on water agar. After incubation at room temperature for 1 wk, the presence or absence of *Rhizoctonia* was determined on the basis of colony morphology and hyphal branching. A planting was considered infected when *Rhizoctonia* was isolated from at least one of the 10 plants sampled.

RESULTS

All fungicide treatments increased yields over untreated controls, and all but one fungicide treatment decreased disease severity in both years (Tables 1 and 2). In 1982, environmental conditions were more favorable for disease development in the first than in the second planting. Yields were variable because of aster yellows infection in the first trial of 1983 and weather-related problems in the second; however, yield increases associated with bottom rot control were similar in both years. Disease severity was lowest in plots treated with iprodione at 2.3 kg/ha, but substantial control was also obtained at 1.7 kg/ha. Increasing the number of iprodione applications from two to three did not significantly improve disease control or yields.

Iprodione was effective in reducing disease severity and increasing marketable yield in all of the commercial plantings in 1982 (Table 3). Disease severity was highest in untreated areas at Berlin fields harvested between 10 July and 18 August 1982. Treatment with iprodione resulted in yield increases of 52 to 331% over the untreated controls in 1982. Conditions were so favorable for disease development in a field planted on 14 June that, despite yield differences between treated and untreated areas, the level of disease was still commercially unacceptable. Disease pressure was less severe in 1983 in the Coloma fields, and significant differences in yield between treated and untreated acreages were not observed. These fields were relatively new to lettuce production and did not have a history of serious bottom rot as the Berlin fields did.

Infection of lettuce plants by *Rhizoctonia* occurred as early as 4 wk after planting in midseason plantings (Table

Table 1. Effects of fungicide sprays on severity of bottom rot on commercial lettuce plantings, Berlin, WI, 1982

Treatment (rate per hectare)	Planting 111 (16 May)			Planting 159 (10 July)		
	Disease index[a]	Yield[b] (cases/acre)	Average yield increase over check (%)	Disease index	Yield (cases/acre)	Average yield increase over check (%)
Benomyl 50W (1.7 kg + 1.7 kg)[c]	57.1	653.4	164.4	39.1	265.3	4.0
Propiconazole 3.6E (0.3 L)[d]	53.8	578.7	134.2	34.3	322.8	26.6
Propiconazole 3.6E (0.3 L + 0.3 L)[c]	38.8	834.0	237.5	31.6	309.5	21.4
Propiconazole 3.6E (0.6 L)[d]	58.1	611.1	147.3	33.0	291.3	14.2
Propiconazole 3.6E (0.6 L + 0.6 L)[c]	46.6	710.0	187.3	...	...	...
Iprodione 50W (1.7 kg + 1.7 kg)[c]	46.0	716.0	189.8	31.4	340.9	33.7
Iprodione 50W (2.3 kg + 2.3 kg)[c]	38.3	823.7	233.3	27.8	489.1	91.8
Iprodione 50W (2.3 kg + 2.3 kg + 2.3 kg)[e]	...	...	...	26.9	418.4	64.1
Vinclozolin 50W (2.3 kg + 2.3 kg)[c]	71.8	486.1	96.7	30.5	385.1	51.0
Untreated control	83.2	247.1	...	36.2	255.0	...
FLSD ($P = 0.05$)	22.5	212.8	...	NS	NS	...

[a] Disease index = [sum of (disease class × number of heads in class) × 100]/total number of harvested heads × 3.
[b] Each case contained 24 heads of lettuce.
[c] Treatments applied 4 and 6 wk after seeding.
[d] Treatments applied 4 wk after seeding.
[e] Treatments applied 4, 5, and 6 wk after seeding.

3). Early infection appeared to be associated with warm, humid weather and poor drainage. In early and late plantings when weather was cool and dry, infection was not detected until 6 wk or more after planting. In fields where infection occurred early, the disease index calculated at harvest was generally higher than in fields where infection was detected later.

DISCUSSION

Iprodione was effective in suppressing bottom rot of lettuce grown on organic soils in Wisconsin. Two applications with 2.3 kg/ha of a iprodione 50WP formulation at 4 and 6 wk gave adequate control of bottom rot under most conditions. Three applications, at 2, 4, and 6 wk, did not provide significantly better protection. During the first 4 wk after seeding, plant growth is upright and microclimate conditions are usually unsuitable for *Rhizoctonia* infection. Thus treatment at 2 wk after seeding has a minimal effect on disease development. As plants mature, the lowest leaves spread over the soil beneath the plant and create a microenvironment of high relative humidity that, at high temperature, is favorable for infection by *Rhizoctonia*. Sprays at 4 and 6 wk provided protection when directed at the bases of plants and the undersides of lower leaves, where initial infection typically occurs. Control was aided by a sprayer designed to provide a directed spray and to follow row contours, with nozzles mounted on drops and swivels for adjustments to match changes in plant growth.

The first registration of iprodione for use on a vegetable crop was a Section 18 label for use on lettuce in Wisconsin in 1982 (5). Treatment with iprodione in commercial plantings prevented considerable economic loss in 1982 in fields with a history of severe bottom rot problems. Many fields probably would not have been harvested in 1982 without the decrease in disease and increase in yield attributed to fungicide applications. On the basis of an average market value of $4.41/case for the 1982 growing season and a total of 150.7 ha harvested at the Berlin site, an increased crop value of about $123,000 was calculated.

Many fungicide treatments have been suggested for the control of bottom rot of lettuce. Townsend and Newhall (8) included an application of 2% ethyl mercury phosphate dusted under nearly mature plants. In greenhouse-grown lettuce, quintozene gave good control of bottom rot (2). A combination of growing the lettuce plants on ridges and applying benomyl or chlorothalonil resulted in significant control in experiments in New York (3). None of these fungicides have been approved for commercial use on lettuce, however. In Wisconsin, lettuce is grown on beds, which allow adequate spray coverage on the lower leaves and bases of plants, and plants dry out quickly. Under these conditions, our results show that iprodione is the preferred fungicide if applied as a directed spray at 4 and 6 wk after planting. Iprodione 50WP was registered for use on commercial head lettuce in 1983 to control both bottom rot (*R. solani*) and lettuce drop (*Sclerotinia* spp.).

Table 2. Effects of fungicide sprays on severity of bottom rot on commercial lettuce plantings, Waupun, WI, 1983

Treatment (rate per hectare)	First planting (15 July harvest)			Second planting (14 Sept. harvest)		
	Disease index[a]	Yield[b] (cases/acre)	Average yield increase over check (%)	Disease index	Yield (cases/acre)	Average yield increase over check (%)
Propiconazole 3.6E (0.3 L)[c]	32.6	536.3	10.9	16.4	665.3	20.0
Propiconazole 3.6E (0.3 L + 0.3 L)	22.9	629.0	30.0	9.1	694.7	25.3
Propiconazole 3.6E (0.6 L)[d]	24.1	608.0	25.7	15.8	663.7	19.7
Iprodione 50W (2.3 kg + 2.3 kg)[d]	16.4	661.7	36.8	10.0	758.3	36.8
Iprodione 50W (2.3 kg + 2.3 kg + 2.3 kg)[e]	12.6	649.3	34.2	10.1	679.7	22.6
Vinclozolin 4F (2.4 L + 2.4 L)[d]	26.9	550.7	13.9	15.0	662.7	19.6
Untreated control	46.6	483.7	···	16.7	554.3	···
FLSD ($P = 0.05$)	14.1	NS	···	4.5	NS	···

[a] Disease index = [sum of (disease class × number of heads in class) × 100]/total number of harvested heads × 3.
[b] Each case contained 24 heads of lettuce.
[c] Treatments applied 4 wk after seeding.
[d] Treatments applied 4 and 6 wk after seeding.
[e] Treatments applied 4, 5, and 6 wk after seeding.

Table 3. Time of intital *Rhizoctonia* infection, index of bottom rot severity, and yields in commercial lettuce plantings treated with iprodione 50W and in untreated checks, Berlin, WI, 1982 and Coloma, WI, 1983[a]

Date of planting	Infection[b] (weeks after planting)	Disease index[c]		Yield (cases/acre)[d]		Yield increase (%)
		Treated	Untreated	Treated	Untreated	
			1982 (Berlin)			
26 April	9	12	37	671	532	26
10 May	8	14	84	965	224	331
20 May	6	51	80	487	321	52
28 May	6	31	73	538	200	169
5 June	4	43	86	599	···	···
14 June	4	69	91	378	142	166
23 June	6	29	67	···	···	···
2 July	7	12	43	756	584	29
10 July	8	19	20	560	457	22
19 July	8	12	27	835	641	30
Average	···	27	61	643	387	103
			1983 (Coloma)			
24 May	···	1.4	3.7	1,137	1,065	7
8 June	···	4.6	7.8	617	484	27
15 June	···	4.1	10.6	690	750	−8
24 June	···	0.0	0.8	750	732	2
3 July	···	4.5	5.4	835	756	10
Average	···	2.9	5.7	806	757	8

[a] Treatments were applied 4 and 6 wk after seeding.
[b] *Rhizoctonia* was isolated from at least one of 10 plants sampled weekly in untreated checks.
[c] Disease index = [sum of (disease class × number of heads in class) × 100]/total number of harvested heads × 3.
[d] Each case contained 24 heads of lettuce.

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