Table 2. Effects of fungicides on early blight severity and yields of 'Florida Slobolt' celery in experiment 2, planted 11 March 1988.

Treatment[z]	Rate (lb. ai/acre)	Formulation[y]	Spray interval (days)	Disease[x] severity (%)	Marketable yield (55 lb. cts/acre)
Untreated Check	—	—	—	42.2 a[w]	869 b
Mancozeb 200	1.6	80DF	7	6.0 cde	1075 a
Mancozeb 200	1.6	80DF	7	4.2 de	1077 a
+ Copper	1.0	50W	7		
Chlorothalonil 720	1.5	6F	7	5.6 cde	1053 a
Chlorothalonil C/M	3.4	85DF	7	3.2 e	1088 a
Chlorothalonil C/M	5.1	85DF	7	2.8 e	1081 a
Propiconazole	0.11	3.6E	7	5.4 de	1111 a
Propiconazole	0.11	3.6E	14	12.4 bc	1057 a
Propiconazole alternated	0.11	3.6E	7	7.3 cde	1021 ab
with Mancozeb 200	1.6	80DF			
Propiconazole alternated	0.11	3.6E	7	4.4 de	1077 a
with Chlorothalonil 720	1.5	6F			
Propiconazole	0.11	3.6E	7	4.2 de	1101 a
+ Copper	1.0	50W	7		
Penconazole	0.12	25W	7	11.1 cd	1050 a
Penconazole	0.12	25W	14	18.2 b	973 ab

[z]Chlorothalonil 720 = Bravo 720; Chlorothalonil C/M = Chlorothalonil + maneb + copper oxychloride = Braco C/M; Propiconazole = Tilt; Mancozeb 200 = Manzate 200; Penconazole = Spotless; Copper = copper hydroxide = Kocide 101.
[y]F = Flowable; W = Wettable powder; WDG = Wettable dispersible granules; DF = Dry flowable; E = Emulsifiable concentrate.
[x]Percent early blight severity on terminal and penultimate trifoliolates of 5 randomly selected petioles emerging from stalk at a 45-60 degree angle.
[w]Mean separation by Duncan's Multiple Range Test, P=0.05.

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EFFICACY OF FOSETYL-ALUMINUM FOLIAR APPLICATIONS IN CONTROLLING DOWNY MILDEW OF LETTUCE

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Abstract. **Two field studies were conducted during 1989 to evaluate the efficacy of fosetyl-Aluminum (fosetyl-Al) at 2 rates of application, alone and in combination with 2 broad-spectrum fungicides, for control of downy mildew of lettuce (*Lactuca sativa* L.) caused by *Bremia lactucae* Regel. Fosetyl-Al treatments provided for significant reductions in disease severity with respect to the untreated check. Disease severities in the 1.6 lb. ai/acre fosetyl-Al treatment were significantly lower than those in the 0.8 lb. ai/acre fosetyl-Al treatment. When applied in combination with mancozeb or chlorothalonil, fosetyl-Al, at rates of 1.6 and 0.8 lb. ai/acre, provided for significant increases in marketable yield over the untreated check.**

The poor performance of a metalaxyl/chlorothalonil treatment in these trials suggested the presence of a metalaxyl-insensitive strain of *B. lactucae*. The existence of such a strain in Florida was confirmed by 2 independent sources using a seedling drench bioassay.

The bulk of Florida's lettuce production is located on the organic Histosols of the Everglades Agricultural Area, situated on the southeast corner of Lake Okeechobee. During the 1987-88 growing season, this area produced approximately 87% of the 11,700 acres of Florida lettuce harvested (5). The remainder of the state's $60 million crop was produced in central Florida near Zellwood.

Downy mildew, caused by *Bremia lactucae* Regel, is potentially the most devastating fungal disease of lettuce in Florida. Characterized by its ability to cause extensive losses in short periods of time, this obligate parasite is highly

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dependent upon the presence of free moisture during cool or warm, but not hot, periods (1). Losses are due primarily to reductions in marketable yield prior to harvest and deterioration in postharvest quality during transit and storage (9). Downy mildew is most often observed during the winter and early spring growing seasons, however, the occurrence of epidemics in Florida is sporadic from year to year.

Control strategies deployed against downy mildew include the use of resistant cultivars, fungicidal sprays, crop rotations, and cultural practices which do not favor propagation of the pathogen (10). The *B. lactucae*/lettuce interaction is a classic gene-for-gene relationship (4, 7). A minimum of 13 single dominant resistance genes and matching complementary pathogen avirulence genes have been described (9). The host/pathogen relationship of *B. lactucae* on Florida lettuce cultivars using local isolates has not been previously studied. However, the 2 major crisphead cultivars presently grown in Florida, Southbay and Raleigh, have demonstrated their susceptibility to Florida downy mildew strains. Together these cultivars account for nearly 99% of the state's crisphead lettuce production.

Prior to 1986, maneb (ethylene bisdithiocarbamate or EBDC) and Cu compounds were the fungicides of choice for controlling lettuce downy mildew. Their efficacy was inconsistent and at times questionable (10). Approval of a section 24C special local needs registration in 1986, specifically for metalaxyl/EBDC tankmix applications, provided Florida growers with a reliable chemical control for the first time. Requirements for a tankmix were intended to impede development of metalaxyl-insensitive strains. Insensitivity of *B. lactucae* strains to metalaxyl has already been reported in California (9) and Great Britain (3). Alternating applications with 2 or more fungicides has proven to be an effective control strategy for certain fungicide-resistant pathogens (2). Fosetyl-aluminum (fosetyl-Al) has been reported as exhibiting activity against various pathogens in the Oomycete class (2) and has a mode of action unrelated to that of metalaxyl. The dissimilarity in modes of action would appear to limit probabilities for cross resistance. The objective of this investigation was to determine the efficacy of fosetyl-Al in controlling lettuce down mildew under Florida conditions.

Materials and Methods

Two field experiments were conducted during the 1988-89 growing season to evaluate the efficacy of fosetyl-Al at 2 rates, alone and in combinations, for lettuce downy mildew control. Both studies were conducted in commercial lettuce fields located in the EAA, near Belle Glade. Lettuce of the mildew susceptible cultivar Raleigh was direct-seeded in double-row beds on 3-ft centers. Experiments 1 and 2 were planted in 14 Dec. 1988 and 4 Jan. 1989, respectively. Fields were fertilized according to soil test recommendations and preplant fertilizer applications were disked into the soil prior to planting. Lettuce was thinned at the 4-leaf stage to provide a 12-inch in-row spacing and a plant population of approximately 22,000/acre. Nitrogen (50 lb./acre) was applied as a sidedress at this stage. Experiments were arranged in a randomized complete block design with 4 replications of 8 treatments. Treatment plots consisted of single 30-ft sections of bed separated by 5 ft alleys. Each plot was bordered by 2 nonsprayed guard rows. Fungicidal sprays were applied with a CO_2 backpack sprayer equipped with 2 hollow-cone nozzles/bed delivering 48 gal of water/acre at 30 psi. In the first experiment, downy mildew was visually *estimated* using the Horsfall-Barratt rating scale (6) to assess disease severity on 10 randomly selected leaves (second leaf from the soil surface) per plot. In contrast, direct counts of the number of downy mildew lesions per leaf (second leaf from the soil surface) were made to provide a measure of mildew severity in the second experiment. Disease severity ratings were performed three days prior to harvest. Ten randomly selected heads per experimental unit were harvested and weighed individually. Total fresh weight and the number of heads remaining marketable after trimming were recorded.

Downy mildew was not observed in the Everglades Agricultural Area until 18 Jan. 1989, when sporulating lesions were observed on mature crisphead lettuce approximately one mile from the experiment 1 location. Spray treatments in experiment 1 were initiated on 21 Jan. when the crop was at the 8-10 leaf stage. Additional sprays were applied on 28 Jan. and 5 Feb. for a total of 3 applications. Leaves exhibiting downy mildew sporulation were first observed in the experimental area on 26 Jan. In experiment 2, fungicide treatments commenced on 28 Jan. at the 4-5 leaf stage, with subsequent sprays being applied on 4, 11, and 22 Feb.

Results and Discussion

All fungicide treatments utilizing fosetyl-Al, regardless of rate or combination, provided for significant reductions ($P=0.05$) in lettuce downy mildew in both experiments (Tables 1 and 2). Although differences between the 0.8 and 1.6 lb. ai/acre fosetyl-Al treatments, as indicated by disease severity means, were significant only in experiment 1, the higher fosetyl-Al rate provided for a significant increase in number of marketable heads over the lower rate in both experiments. Tankmix combination of mancozeb with fosetyl-Al at the low rate provided for significant increases in marketable yields over treatment with fosetyl-Al

Table 1. Effects of fungicide treatments on downy mildew severity and yield of lettuce in experiment 1.

Treatment[z]	Rate (lb. ai/acre)	Disease[y] severity (%)	Total weight (lb./head)	Heads marketable (%)
Untreated	—	[x]10.4 a	2.0	25 a
Fosetyl-Al	0.8	6.8 b	2.0	62 bc
Fosetyl-Al	1.6	2.3 c	2.0	85 d
Fosetyl-Al + Mancozeb	0.8 1.2	2.3 c	2.1	85 d
Fosetyl-Al + Mancozeb	1.6 1.2	2.3 c	2.2	98 d
Fosetyl-Al + Chlorothalonil	0.8 0.8	4.3 c	2.2	77 cd
Fosetyl-Al + Chlorothalonil	1.6 0.8	4.3 c	2.1	88 d
Metalaxyl/ Chlorothalonil	1.2	8.7 ab	2.0	50 b

[z]Fosetyl-Al = Aliette 80W; Mancozeb = Manex II 4F; Chlorothalonil = Bravo 720 6F; Metalaxyl/Chlorothalonil = Ridomil/Bravo 81W.
[y]Percent leaf area visibly affected by downy mildew on the second leaf from the soil surface.
[x]Mean separation by Duncan's multiple range test, $P=0.05$.

Table 2. Effects of fungicide treatments on downy mildew severity and yield of lettuce in experiment 2.

Treatment[z]	Rate (lb. ai/acre)	Disease[y] severity (No./Leaf)	Total weight (lb./head)	Heads marketable (%)
Untreated	—	16.5 a[x]	1.9 b	32 a
Fosetyl-Al	0.8	6.8 b	2.0 b	65 bc
Fosetyl-Al	1.6	6.5 b	2.1 ab	90 d
Fosetyl-Al + Mancozeb	0.8 1.2	3.5 b	2.1 ab	85 d
Fosetyl-Al + Mancozeb	1.6 1.2	0.5 b	2.2 a	95 d
Fosetyl-Al + Chlorothalonil	0.8 0.8	5.8 b	2.0 ab	80 cd
Fosetyl-Al + Chlorothalonil	1.6 0.8	5.3 b	2.1 ab	92 d
Metalaxyl/ Chlorothalonil	1.2	6.8 b	1.9 b	55 b

[z]Fosetyl-Al = Aliette 80W; Mancozeb = Manex II 4F; Chlorothalonil = Bravo 720 6F; Metalaxyl/Chlorothalonil = Ridomil/Bravo 81W.
[y]Number of downy mildew lesions visible on the second leaf from the soil surface.
[x]Mean separation by Duncan's multiple range test, P=0.05.

alone at the low rate. Efficacies obtained by addition of mancozeb or chlorothalonil to the low rate of fosetyl-Al were not significantly different from those obtained using the high rate of fosetyl-Al, either alone or in combination. In summary, these results indicate that downy mildew control obtained using the 0.8 lb. ai/acre rate was significantly improved by the addition of a broad spectrum fungicide. Combination of a systemic, such as fosetyl-Al, with the full rate of a broad spectrum compound is also desirable in terms of preventing development of pathogen insensitivity to systemic fungicides (11).

Downy mildew control exhibited by the metalaxyl/chlorothalonil combination was not significantly different from the untreated check in terms of disease severity in experiment 1. Although marketable yield produced in the metalaxyl/chlorothalonil treatment was significantly higher than that of the untreated check, it was significantly lower than all other fungicide treatments, with the exception of fosetyl-Al alone at the low rate. These results were unexpected since metalaxyl had demonstrated excellent downy mildew control in commercial production fields since its 24C registration in 1986. Suspicions of the presence of a metalaxyl-insensitive *B. lactucae* strain were confirmed by 2 independent researchers using assay techniques developed by Crute (3) on isolates collected from the experimental area (8). This was the first reported incidence of insensitivity of *B. lactucae* to metalaxyl in Florida. The origin of the metalaxyl-insensitive strain has not been ascertained. However, in terms of pathotype and mating type, it was identical to a metalaxyl-insensitive strain reported in California (9). Transport of this particular strain from California is a distinct possibility, since California lettuce is routinely shipped to Florida markets and downy mildew may easily survive cold storage during transit.

Fosetyl-Al has recently received a section 18 registration for lettuce downy mildew control in Florida. Since resistance to fosetyl-Al has been demonstrated for other host/pathogen interactions (2), it is recommended that Florida *B. lactucae* populations be monitored closely for sensitivity to both metalaxyl and fosetyl-Al. This knowledge will assist scientists and growers in developing useful strategies to prolong the effectiveness of these valuable fungicides for controlling lettuce downy mildew.

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