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Note

Control of Potato Late Blight by Cyazofamid

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To evaluate the efficacy of the novel fungicide cyazofamid against potato late blight, 5 field tests were carried out in 1998–2000. Cyazofamid provided excellent control of late blight in the field. In preventative scheduled application tests, the efficacy of cyazofamid at dose rates of 67 and 100 μg active ingredient (a.i.)/ml with 10-day and 14-day intervals, respectively was superior to that of mancozeb at 1875 μg a.i./ml with a 7-day interval. The spray program that included cyazofamid was equal or superior to the standard spray program in Hokkaido, Japan. In the curative application test, cyazofamid suppressed the development of late blight. Cyazofamid will be useful in spray programs for the control of late blight in potato cultivation. © Pesticide Science Society of Japan

Keywords: cyazofamid, IKF-916, *Phytophthora infestans*, potato late blight, field test.

INTRODUCTION

Late blight caused by *Phytophthora infestans* (Montagne) de Bary is one of the most serious diseases in potato cultivation worldwide.[1] Heavy infection of foliage by this pathogen leads to severe losses of potato quality and yield. Although mancozeb is widely used to control late blight in Japan, this fungicide needs a high use rate to achieve satisfactory effects and should be applied at 7-day intervals.

Cyazofamid, 4-chloro-2-cyano-*N*,*N*-dimethyl-5-*p*-tolylimidazole-1-sulfonamide, IKF-916 (development code), Ranman® is a novel fungicide highly active against fungi of Oomycetes[2–6] and *Plasmodiophora*.[7] We previously reported that cyazofamid at 80 g active ingredient (a.i.)/ha with 300 liters/ha of application volume, which corresponds to 67 μg a.i./ml with 1200 liters/ha of application volume, exhibited excellent activity against potato late blight in the field.[2–4] The data also indicated that cyazofamid achieved significant control of tuber infection by *P. infestans*.[3,4] But there was little data available concerning the field evaluation of cyazofamid at the rate recommended in Japan (67–100 μg a.i./ml) against potato late blight.

The purpose of this study was to evaluate the activity against potato late blight of cyazofamid at the Japanese recommended dose rate and different application intervals in the field. Effects of curative application of cyazofamid and of preventative application in rotation with other fungicides were also evaluated.

MATERIALS AND METHODS

1. Location

Five tests were conducted in Tokachi district (1998–2000) and Nakagawa district (2000), Hokkaido, Japan. The tests were laid down as randomized plots (6 m^2, 2.4×2.5 m), replicated 2 times with 25 plants/plot. Seed potato tubers (variety Konafubuki and Dansyaku; Irish cobbler) were sown into the soil between the end of April and beginning of May.

2. Fungicides

Cyazofamid (100 g/liter suspension concentrate (SC), Ranman®, Ishihara Sangyo Kaisha Ltd.), mancozeb (75% wettable powder (WP), Green Dithane®, Hokkai Sankyo Co., Ltd.), fluazinam (50% WP, Frowncide®, Ishihara Sangyo Kaisha Ltd.) and premixture fungicide cymoxanil+chlorothalonil (24+60% WP, Blizzard®, Nihon Nohyaku Co., Ltd.) were used in this study. All fungicides were suspended in water containing 0.02% (v/v) of a surfactant, Gramin S (Hokkai Sankyo Co., Ltd.), immediately before use.

3. Applications

Applications were made using a knapsack sprayer with a motor (SHR045, Kioritz Corporation) to simulate the practical applications by farmers (water volume: 1200 liter/ha). Initiation of the application was generally adapted to local practice in Hokkaido, Japan, starting from BBCH (Biologische Bundesanstalt, Bundessortenamt and Chemical Industry) 55–65 (pre to full flowering) until BBCH 85–87 (maturity). The application conditions are listed in Table 1.

4. Evaluation

In every assessment, 20 plants per plot in the central part of the plot were evaluated. Percentage of disease development of the plants was rated on a scale of 0 (no disease) to 8 (more than 90% infested) according to the reported method with some modifications.[8] The efficacy of the compounds for late blight control on potatoes was expressed in terms of disease severity using the following formula:

$$\text{Disease severity} = \sum(\text{scale} \times \text{number of plants}) \times 100 / 8 \times 20$$

Tuber infection by *P. infestans* was evaluated after the final evaluation of foliage infection. Crop tolerance was also evaluated in all the trials before every application.

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Table 1. Application conditions for evaluation of cyazofamid against potato late blight in the field[a)]

Year	District (Application timing)	Date of first disease symptoms	Date of final evaluation	Application interval (days)	Number of applications	Date of application
1998	Tokachi (Preventative)	Aug. 12	Sept. 10	7	10	June 30, July 7, 14, 21, 28, Aug. 5, 10, 17, 24, Sept. 1
				10	7	June 30, July 11, 21, Aug. 1, 10, 21, Sept. 1
				14	5	June 30, July 14, 28, Aug. 10, 24
1999	Tokachi (Preventative)	Aug. 24	Sept. 10	7	8	July 2, 9, 16, 23, 30, Aug. 6, 13, 20
				10	6	July 2, 12, 22, Aug. 2, 11, 21
				14	4	July 2, 16, 30, Aug. 13
				7/10/7	7	July 2, 9 / July 16, 26, Aug. 5 / Aug. 15, 22
2000	Tokachi (Preventative)	Aug. 2	Sept. 7	7	8	July 3, 10, 17, 24, 31, Aug. 7, 14, 20
				10	6	July 3, 13, 23, Aug. 2, 12, 23
				7/10/7	7	July 3, 10, 17 / July 24, Aug. 3 / Aug. 13, 20
				7/10/10	6	July 3, 10, 17 / July 24, Aug. 3 / Aug. 13
	Nakagawa (Preventative)	July 10	Aug. 18	7	7	June 30, July 7, 14, 21, 28, Aug. 3, 11
				10	5	June 30, July 10, 20, 30, Aug. 10
				14	4	June 30, July 14, 28, Aug. 11
				7/10/7	6	June 30, July 7 / July 14, 24 / Aug. 3, 10
				7/10/10	6	June 30, July 7 / July 14, 24 / Aug. 3, 13
	Nakagawa (Curative)	July 10	Aug. 18	7	5	July 15, 21, 28, Aug. 4, 11

[a)] Water volume: 1200 liter/ha, variety: Konafubuki (Tokachi district in 1998–2000), Dansyaku; Irish cobbler (Nakagawa district in 2000). Field tests were laid down as randomized plots (2×2.4 m) with 2 replicates.

RESULTS AND DISSCUSSION

1. Preventative Scheduled Application

1.1. Field test in 1998—Effect of cyazofamid solo

Severe disease pressure occurred in 1998. The first symptoms of late blight were observed on August 12 (Table 1), and the untreated control exhibited 100% foliar destruction on Sept. 6 (data not shown).

Even in the case of heavy infestation, cyazofamid (100 μg a.i./ml) exhibited excellent control of late blight (Table 2). The efficacy of cyazofamid with 10-day and 14-day application intervals was superior to that of mancozeb (1875 μg a.i./ml) with a 7-day interval.

1.2. Field tests in 1999

1.2.1. Effect of cyazofamid solo

The first symptoms of late blight appeared very late due to unfavorable weather conditions for the pathogen (high temperature and a small amount of rain), being first observed on Aug. 24 (Table 1). Thereafter, the infestation spread rapidly with the untreated control exhibiting 85% foliar destruction on Sep. 10 (Table 2).

All fungicides tested exhibited some degree of activity against late blight. Among them, cyazofamid (67 and 100 μg a.i./ml) with 10-day application intervals gave the best control of late blight. With 14-day application intervals, cyazofamid (100 μg a.i./ml) exhibited similar control of the disease as fluazinam (333 μg a.i./ml). The efficacy of cyazofamid with 10- and 14-day application intervals was superior to that of mancozeb (1875 μg a.i./ml) applied at 7-day intervals.

1.2.2. Effect of alternative applications with other fungicides

Since it is extremely unlikely that cyazofamid alone will be used for an entire season, the effect of alternative applications with other fungicides was also evaluated. The first symptoms of disease in the untreated control appeared on Aug. 24. Cyazofamid was used in the rotation program between July 16 and Aug. 5 (Table 1). Leaves from the plots treated with the spray program that included cyazofamid (2 sprays of mancozeb, followed by 3 sprays of cyazofamid, and again 2 sprays of mancozeb) had lower incidences of infection by *P. infestans* than those from the plots treated with mancozeb alone (1875 μg a.i./ml, 7-day intervals, 8 sprays, Table 2). The activity was equal to that in plots sprayed with cyazofamid alone (67 and 100 μg a.i./ml, 10-day application intervals, 6 sprays). Since cyazofamid possesses strong activity to inhibit the formation of zoosporangia,[5)] it may contribute to a decrease in the density of zoosporangia in the field.

Table 2. Preventative activity of cyazofamid against *Phytophthora infestans* on potatoes in 1998 to 2000

Application type	Compounds	μg a.i./ml	Application interval (days)	Disease severity[a)]			
				1998 Tokachi	1999 Tokachi	2000 Tokachi	2000 Nakagawa
Solo	Cyazofamid	67	10	—	1 a	19 a	7 a
		100	10	9 a	3 a	—	—
		100	14	16 a	12 b	—	5 a
	Fluazinam	333	14	—	8 b	—	6 a
	Mancozeb	1875	7	37 b	22 c	47 c	11 b
Rotation program	M,M,/C,C,C,/M,M[b)]		7/10/7	—	3 a	—	—
	M,M,M,/C,C,/M,M		7/10/7	—	—	21 ab	—
	M,M,M,/F,F,/C		7/10/10	—	—	24 ab	—
	M,M,/F,F,/C,C		7/10/10	—	—	—	3 a
	M,M,M,/F,F,/M,M		7/10/7	—	—	29 b	—
	M,M,/F,F,/M,M		7/10/7	—	—	—	7 a
	Untreated control	—	—	100 c	85 d	100 d	100 c

[a)] Values followed by the same letter in the same column are not significantly different according to the Duncun's multiple range test (p=0.05). [b)] Where indicated, mancozeb (1875 μg a.i./ml) with a 7-day application interval (M), cyazofamid (67 μg a.i./ml) with a 10-day interval (C), and fluazinam (333 μg a.i./ml) with a 10-day interval (F), were used.

1.3. Field tests in 2000

1.3.1. Effect of cyazofamid solo

Two field tests were carried out in the Tokachi district and in the Nakagawa district. Severe disease pressure occurred in 2000. In the Tokachi district, the first symptoms of late blight were observed on Aug. 2 (Table 1) and the untreated control exhibited 100% foliar destruction on Aug. 30 (data not shown). Even in the case of heavy infestation, cyazofamid exhibited excellent control of late blight (Table 2). The efficacy of cyazofamid (67 μg a.i./ml) with the 10-day application intervals was superior to that of mancozeb (1875 μg a.i./ml) with the 7-day intervals.

In the Nakagawa district, the first symptoms of late blight were observed on July 10 (Table 1) and the untreated control exhibited 100% foliar destruction on Aug. 4 (data not shown). Even in the case of heavy infestation, cyazofamid at 67 and 100 μg a.i./ml with 10-day and 14-day application intervals, respectively, exhibited excellent control of late blight, and was superior to mancozeb at 1875 μg a.i./ml with a 7-day interval (Table 2). Cyazofamid at 67 and 100 μg a.i./ml with 10-day and 14-day application intervals, respectively, exhibited a similar degree of control to fluazinam at 333 μg a.i./ml used at 14-day intervals.

1.3.2. Effect of alternative applications of other fungicides

In the Tokachi district, two different spray programs utilizing cyazofamid (3 sprays of mancozeb, followed by 2 sprays of cyazofamid and another 2 sprays of mancozeb; and 3 sprays of mancozeb, followed by 2 sprays of fluazinam and 1 spray of cyazofamid), were equal or superior to the standard spray program used in Hokkaido (total of 7-9 sprays, mancozeb, followed by fluazinam and again mancozeb, with the number of applications of each fungicide depending on weather conditions and the growth stage of potatoes in the district).

In the Nakagawa district, the spray program that included cyazofamid (2 sprays of mancozeb, followed by 2 sprays of fluazinam and 2 sprays of cyazofamid) was equal in effect to the standard application. On the basis of the results together with the results in 1999 (Table 2), it can be concluded that cyazofamid provides excellent control of late blight when it is applied alternately with other fungicides like mancozeb.

2. Curative Scheduled Application, Field Test in 2000—Effect of Cyazofamid Solo

The first application of fungicide was begun on July 15 (disease severity: 41–48) after the infestation had rapidly spread. The untreated control suffered 100% destruction within 3 weeks (Aug. 4). Cyazofamid (100 μg a.i./ml) applied at 7-day intervals clearly reduced the development of blight symptoms compared with the untreated control (Fig. 1). The curative pre-mixture cymoxanil+chlorothalonil (300+750 μg a.i./ml) had a similar effect on the development of the disease as cyazofamid. Although cyazofamid had a limited curative effect on *P. infestans* in pot tests,[5)] it was able to suppress the diseases development after the pathogen had infected the plants in the field (Fig. 1). This observation is consistent with the results of those from cucumber downy mildew field experiment in Japan.[6)] However, in order to fully benefit from its very strong preventative activity, one would have to apply cayzofamid before the infection occurred.

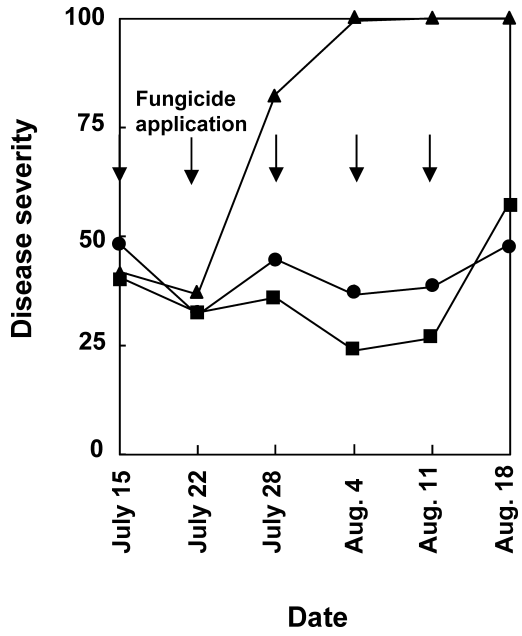

Fig. 1. Effect of curative application of cyazofamid on potato late blight. Fungicide: —●—, Cyazofamid (100 μg a.i./ml); —■—, Cymoxanil+Chlorothalonil (300+750 μg a.i. /ml); —▲—, None (untreated control).

3. Crop Tolerance and Tuber Infection in 1998–2000

No phytotoxic symptoms were observed with repeated applications of cyazofamid, with rates of up to 100 μg a.i./ml in 5 tests under various field conditions (data not shown).

Tuber infection by *P. infestans* was not observed in any of the trials even in the untreated control (data not shown).

4. Conclusion

Cyazofamid provided a high level of control at a very low seasonal use rate as compared with commercial fungicides. Overall, we can conclude that 67 μg a.i./ml cyazofamid applied at 10-day intervals and 100 μg a.i./ml cyazofamid applied at 14-day intervals was superior to 1875 μg/ml mancozeb used at 7-day intervals. The use of fungicides which can be applied at 10 to 14-day intervals, reduces the total number of applications saving labor and money. The mode of action of cyazofamid differs from that of other currently registered and commonly used fungicides.[9–11] Therefore, cyazofamid will become an excellent tool for use in fungicide resistance management strategies.[10,11]

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