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Efficacy of Different Fungicides for the Control of Downy Mildew of Onion

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Abstract

An experiment was conducted to evaluate different fungicides, against downy mildew of onion. Six fungicides were tested in field trials conducted at the Sistan region of Iran, in 2010 and 2011. Each of the fungicides was sprayed three times at an interval of 10 days, following appearance of the disease symptoms. All the fungicides were found to be effective in controlling the disease. Infinito was the most effective in reducing the disease severity and enhancing yield, followed by Previcur Energy and Consento. Sprays with Infinito also resulted in the least number of dead plants, most abundant leaves per plant, and largest number and weight of medium, large and total bulbs.

Keywords: *Allium cepa; Peronospora destructor;* Downy mildew; Fungicide; Chemical control

Introduction

Onion is an important vegetable of the Iran and 3rd most grown horticultural crop, after potato and tomato, covering an area of 50,000 hectares with 1800,000 tonnes annual production [1]. Downy mildew caused by *Peronospora destructor* is one of the most severe diseases of onions, if not controlled adequately. Slightly pale spots develop first, later taking on a light brown or purplish shade. Plants often are not killed, but bulb quality is poor and often spongy. Lesion-weakened seed stems may break, causing seed to shrivel [2]. Successive leaves are attacked, until the only youngest ones remain. The bulbs of such plants are unable to develop fully, and are immature [3]. Under high humidity for longer periods, furry fungus growth becomes wide spread, and an epidemic occurs if fungicides are not applied [4]. Many research workers have reported the control of the disease, through the use of fungicides [5-12].

To minimize the losses, use of resistant variety is the ideal way, but it is one of the worst diseases affecting almost every variety. Under such conditions an alternative control measure, is the use of chemicals. A number of chemicals have been evaluated by different Scientists, to control the disease. Among these fungicides, Metalaxyl and Cyomaxanil have proved the most effective in reducing the disease intensity, from 72- 88% [9]. Highly significant control of the disease was obtained with Ridomil M Z-71 WP [13]. The present studies were carried out to find the new suitable chemical, for the control of the said disease.

Materials and Methods

The experiment was conducted at Agriculture and Natural Resources Research Center of Sistan, Iran in 2010 and 2011. Onion variety Texas Early Grano, was planted in rows 2m long and 20 cm apart. Different fungicides (Table 1) were used, along with an untreated check. Each treatment was applied to five adjacent rows in a randomized complete block design, and replicated three times.

Raising of nursery and transplantation of seedlings

Seed of the variety was sown in nursery beds. Fifty days after sowing, uniform and healthy seedlings were transplanted to the field. Farm yard manure, irrigation and other cultural practices, were done as usual. The inoculum of downy mildew was collected from the neighboring area, and its identity confirmed by microscopic examination. A suspension was made with distilled water, following the method of Gilles et al. [14]. The fungal spores in the distilled water were sprayed on onion plants, after adjusting spore concentration at 1×10^4 sporangia ml^{-1} with the help of a haemocytometer. The inoculation was done early in the morning, when the prevailing temperature and relative humidity were conducive for infection.

No	Treatments	Active Ingredients	Dosage rate/ha
1	Acrobat MZ 690 WP	dimethomorph 90 g/kg + mancozeb 600 g/kg	2 kg
2	Agri-fos 400 L 40%	Mono and Di potassium Phosphonate 400 g/l	51
3	Consento 450 SC	propamocarb HCL 375 g/l + fenamidon 75 g/l	2.51
4	Equation Pro WG	famoxadone 22.5% + cy-moxanil 30%	0.5 kg
5	Infinito SC 687.5	propamocarb HCL 625 g/l + fluopicolide 62.5 g/l	1.61
6	Previcur Energy 840 SL	propamocarb 530g/1 + fosetyl 310g/1	2.51
7	Only distilled water (control)		

Table 1: Fungicides and their doses used in the study

Treatments

At the appearance of the disease symptoms, the scheduled spray programme was started at an interval of 10 days. The fungicides in Table 1 were sprayed on the crop.

Data recording and analysis

Data were taken on the following parameters: disease severity, number of leaves per plant, number and weight of small, medium and large size bulbs. Data on disease severity were recorded after the first appearance of downy mildew symptoms and after each spray, following 1-9 rating scale of [15] presented in Table 2. Area under disease progress curve (AUDPC) was calculated by using the formula [16], to determine the disease progression.

$$AUDPC = \sum_{i=1}^{n} [(X_i + X_{i-1})/2] [t_i - t_{i-1}]$$

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Whereas x_i=Present disease severity; x_{i-1}=Previous disease severity; t_i-t_{i-1}=Time difference between two consecutive disease severities.

Yield data were recorded at the time of harvest of the crop. All statistical analyses were conducted using MSTAT-C software v.11.0, and when means were significantly different, mean separations were calculated using the least significant difference (LSD) test, with significance at p=0.05.

Results

Disease severity

In 2010 and 2011, significant differences in disease severity were observed among the different treatments (Table 3 and 4). The lowest disease severity value of 9.107% in 2010, and 9.903% in 2011 was recorded in treatment with Infinito, while the highest value of 69.31% in 2010 and 67.34% in 2011, and was in the unprotected check. The other treatments where different fungicides were sprayed, also resulted in lower disease severity than the unprotected check.

Area under disease progress curve (AUDPC)

In 2010 and 2011, fungicide treatments resulted in lower AUDPC than the unprotected check (Table 3 and 4). However, significant differences were found among the fungicide treatments. The lowest (113.0 in 2010 and 116.1 in 2011) AUDPC was recorded for plants treated with Infinito, while the highest (266.4 in 2010 and 264.2 in 2011) AUDPC was recorded for treatment Agri-fos. Infinito showed 84.69% in 2010 and 84.12% in 2011 lower AUDPC value, than the unprotected check.

Percentage of infected leaves

In 2010 and 2011, significant differences were observed among the different treatments (Table 3 and 4). The minimum percentage (31.95% in 2010 and 30.10% in 2011) of infected leaves was recorded in Infinito treated plants, while the maximum percentage (87.39% in 2010 and 83.41% in 2011) of infected leaves was recorded in the unprotected check.

Total number of leaves

In 2010 and 2011, significant differences among different treatments were recorded (Table 3 and 4). The maximum number of total leaves (96.33 in 2010 and 95.50 in 2011) occurred on plants treated with Infinito, whereas the minimum number of total leaves (31.00 in 2010 and 28.10 in 2011) was observed in the unprotected check, where no fungicide was applied.

Key scale	Description	Disease severity (Percent)
1	No symptoms	0
2	Only few leaves affected	1
3	Less than half of the plants affected	5
4	Most of the plants affected, attack is restricted to one leaf per plant	10
5	All plants affected, attack restricted to one or two leaves	20
6	Three to four leaves of each plant affected, crop looks fairly green	50
7	All leaves affected, crop gives blighted appearance	75
8	All leaves severely affected, greenness restricted to central shoot only	90
9	Foliage completely blighted	100

Table2: Assessment key for downy mildew of onion (Mohibullah, 1992).

Treatment	Mean disease severity (%)	Mean value of AUDPC	% infected leaves	Mean number of total leaves	Mean number of dead plants	Mean number of living plants
Acrobat MZ	24.39b*	251.9bc	49.50bc	77.50de	10.17c	19.00c
Agri-fos	25.60b	266.4b	53.31b	75.00e	11.00b	19.23c
Consento	13.88d	142.8d	40.73d	86.67bc	5.500e	26.00b
Equation Pro	22.12c	237.2c	44.93cd	82.00cd	8.167d	21.00c
Infinito	9.107f	113.0e	31.95e	96.33a	2.980g	32.00a
Previcur Energy	11.91e	124.4e	39.10d	90.33b	4.500f	28.00b
Control	69.31a	734.1a	87.39a	31.00f	19.87a	14.00d
LSD (0.05)	1.343	15.09	6.415	5.749	0.8074	2.722
C.V.(%)	3.01	3.18	7.37	4.22	5.2	6.73

*Means within a column followed by the same letter are not significantly different at P = 0.05 according to the least significant difference test.

Table 3: The effect of different fungicides on disease severity and area under disease progress curve (AUDPC) of downy mildew infected onion plants, percentage of downy mildew infected and total leaves and mean number of dead and living onion plants per treatment in the 2010 trial.

Treatment	Mean disease severity (%)	Mean value of AUDPC	% infected leaves	Mean number of total leaves	Mean number of dead plants	Mean number of living plants
Acrobat MZ	24.41b*	252.2bc	49.52bc	77.70de	10.50b	19.77c
Agri-fos	25.00b	264.2b	53.33b	75.57e	11.50b	19.57c
Consento	13.90d	143.0d	40.75d	87.13bc	5.500d	26.33b
Equation Pro	22.10c	237.4c	44.93cd	82.13cd	8.300c	21.23c
Infinito	9.903f	116.1e	30.10e	95.50a	2.500f	31.17a
Previcur Energy	11.93e	125.8e	39.31d	90.10ab	4.433e	28.20b
Control	67.34a	731.3a	83.41a	28.10f	18.14a	14.60d
LSD (0.05)	1.388	15.32	6.417	6.469	1.028	2.605
C.V.(%)	3.19	3.22	7.32	4.75	6.48	6.32

*Means within a column followed by the same letter are not significantly different at P = 0.05 according to the least significant difference test.

Table 4: The effect of different fungicides on disease severity and area under disease progress curve (AUDPC) of downy mildew infected onion plants, percentage of downy mildew infected and total leaves and mean number of dead and living onion plants per treatment in the 2011 trial.

Average number of dead plants

In 2010 and 2011, significant differences were found among the different treatments (Table 3 and 4). The lowest average number of dead plants (2.980 in 2010 and 2.500 in 2011) was observed in treatment Infinito. The highest average number of dead plants (19.87 in 2010 and 18.14 in 2011) was recorded in treatment, where no fungicide was applied.

Average number of living plants

In 2010 and 2011, there were significant differences among the different treatments (Table 3 and 4). Application of Infinito gave the maximum average number of living plants, while the lowest average number of living plants was recorded in the unprotected check.

Number of small bulbs (<3 cm diameter)

In 2010 and 2011, significant differences were observed among the different treatments (Table 5 and 6). The highest (11.50 in 2010 and 12.00 in 2011) number of small bulbs, was in the treatment where

Infinito was applied, while the unprotected check gave the lowest (1.00 in 2010 and 2011) number of small bulbs.

Weight of small bulbs

In 2010 and 2011, data on the weight of small bulbs revealed significant differences among the treatments (Table 5 and 6). Maximum weight of small bulbs (0.180 kg in 2010 and 0.250 kg in 2011) was recorded in treatments Infinito. The lowest weight of small bulbs (0.030 kg in 2010 and 2011) was recorded in the unprotected check.

Number of medium bulbs (3-5 cm)

In 2010 and 2011, significant differences were found among the different treatments (Table 5 and 6). The highest mean number of medium bulbs (54.00 in 2010 and 55.00 in 2011) was observed in the treatment, where Infinito was applied. This fungicide gave 100% in 2010 and 103.70% in 2011 increase over the unprotected check, where only 27.00 in 2010 and 2011 medium bulbs were registered.

Weight of medium bulbs

In 2010 and 2011, application of Infinito gave the maximum weight (2.190 kg in 2010 and 2.330 kg in 2011) of medium size bulbs (Table 5 and 6). The lowest weight (1.080 kg in 2010 and 1.120 kg in 2011) was obtained in the unprotected check, where no fungicide was sprayed.

Number of large bulbs (>5 cm)

In 2010 and 2011, significant differences were registered among the different treatments (Table 5 and 6). The highest (26.50 in 2010 and 26.50 in 2011) number of large bulbs was recorded in the treatment Infinito, while the lowest number (9.00 in 2010 and 2011) of large bulbs was recorded in the unprotected check.

Weight of large bulbs

In 2010 and 2011, data on the weight of large bulbs showed significant differences among the treatments (Table 5 and 6). Maximum weight of the large bulbs (2.400 kg in 2010 and 2.520 kg in 2011) was recorded in treatment Infinito, whereas the lowest weight of large bulbs (0.820 kg in 2010 and 0.860 kg in 2011) was recorded in the unprotected check.

Treatments	Mean number of small bulbs	Mean weight of small bulbs (kg)	Mean number of medium bulbs	Mean weight of medium bulbs (kg)	Mean number of large bulbs	Mean weight of large bulbs (kg)	Mean total number of bulbs	Mean total weight of bulbs (kg)
Acrobat MZ	4.00d*	0.060cd	37.00de	1.480c	15.50cd	1.390c	56.50cd	2.940c
Agri-fos	4.00d	0.060cd	35.00e	1.400c	14.50d	1.310c	53.50d	2.780c
Consento	7.00b	0.110bc	45.00c	1.800b	22.00b	1.980b	74.00b	3.900b
Equation Pro	5.00c	0.08bcd	39.00d	1.560c	17.00c	1.530c	61.00c	2.880c
Infinito	11.50a	0.180a	54.00a	2.190a	26.50a	2.400a	92.00a	4.800a
Previcur Energy	7.500b	0.120b	49.00b	1.930b	22.50b	2.020b	79.00b	4.080b
Control	1.00e	0.030d	27.00f	1.080d	9.00e	0.820d	37.00e	1.900d
LSD (0.05)	0.6727	0.05626	3.940	0.1866	1.692	0.2250	6.713	0.4968
C.V.(%)	6.61	5.34	5.42	6.40	5.24	7.78	5.83	8.4

*Means within a column followed by the same letter are not significantly different at P = 0.05 according to the least significant difference test.

Table5: The effect of different fungicides on the number and weight of small, medium and large size and total onion bulbs per treatment in the 2010 trial.

Treatments	Mean number of small bulbs	Mean weight of small bulbs (kg)	Mean number of medium bulbs	Mean weight of medium bulbs (kg)	Mean number of large bulbs	Mean weight of large bulbs (kg)	Mean total number of bulbs	Mean total weight of bulbs (kg)
Acrobat MZ	4.00e*	0.070cd	37.00de	1.480d	15.50d	1.410c	56.50cd	2.970e
Agri-fos	3.00f	0.050d	35.00e	1.400d	14.50d	1.350c	52.50d	2.820e
Consento	7.00c	0.110c	45.00c	1.800bc	22.00b	2.000b	74.00b	3.923c
Equation Pro	5.00d	0.080cd	40.00d	1.600cd	18.00c	1.550c	61.00c	3.247d
Infinito	12.00a	0.250a	55.00a	2.330a	26.50a	2.520a	93.50a	5.037a
Previcur Energy	8.00b	0.190b	50.00b	1.970b	23.00b	2.060b	80.50b	4.253b
Control	1.00g	0.030d	27.00f	1.120e	9.00e	0.860d	37.00e	1.983f
LSD (0.05)	0.8679	0.05626	4.477	0.2105	1.902	0.2578	7.822	0.2639
C.V. (%)	8.54	8.57	6.10	7.03	5.82	8.72	6.76	4.33

*Means within a column followed by the same letter are not significantly different at P = 0.05 according to the least significant difference test.

Table6: The effect of different fungicides on the number and weight of small, medium and large size and total onion bulbs per treatment in the 2011 trial.

Total number of bulbs

In 2010 and 2011, the application of Infinito gave the maximum (92.00 in 2010 and 93.50 in 2011) total number of bulbs (Table 5 and 6) which was 148.64% in 2010 and 152.70% in 2011, more than the lowest number of 37.00 in 2010 and 37.00 in 2011 bulbs obtained from the unprotected check, where no fungicide was sprayed.

Total weight of bulbs

In 2010 and 2011, data on the total weight of onion bulbs revealed significant differences among the treatments (Table 5 and 6). Maximum total weight of all onion bulbs (4.800 kg in 2010 and 5.037 kg in 2011) was recorded, when Infinito was applied. The lowest weight (1.900 kg in 2010 and 1.983 kg in 2011) of onion bulbs was recorded, when no fungicide was sprayed.

Discussion

Downy mildew, which causes tremendous losses to onion every year, can be effectively controlled through the use of resistant varieties. However, in the absence of resistant cultivars, fungicides can minimize the disease losses. One of the most common known means of controlling plant diseases in the field, is through the use of chemical compounds that are toxic to the pathogens [17].

In the present study, several fungicides were evaluated to determine their effectiveness against downy mildew. The results showed that Infinito was the most effective, followed by Previcur Energy and Consento. In this study, the application of all the fungicides significantly reduced the disease severity, and consequently increased yield in the fungicide treatments, as compared to the unprotected check. However, the minimum disease severity was recorded in the treatment Infinito followed by Previcur Energy and Consento, while maximum disease severity was observed in the untreated plot. Shaner et al. [16] reported that out of five fungicides used, highly significant control of the disease was obtained with Amistar, Infinito and Signum. The application of fungicides significantly affected the yield, by increasing number and size of onion bulbs. The highest yield was recorded in plot treated with Infinito. This was followed by the plots treated with Previcur Energy

and Consento. In treatment where no fungicide was applied, bulb yield was the lowest indicating that fungicide application helped in increasing bulb yield. The use of these fungicides is recommended in an integrated control strategy, incorporating other methods such as resistant varieties and prudent cultural practices.

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