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Enhancing Yield in Cucumber through Integrated Crop Management

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A B S T R A C T

Downy mildew caused by *Pseudoperonospora cubensis* is one of the most widely spread and economically important disease of cucumber. The present investigation was carried out to evaluate the efficacy of different fungicides and biocontrol agents for the management of the disease. Soil application of *Trichoderma harzianum* through farm yard manure (enrichment – 1kg / 100kg for 15days), seed treatment with Metalaxyl (2.0g/kg seeds). Prophylactic spray – Mancozeb (2.5 g/L) – 3 weeks after planting followed by sprays of Metalaxyl + Mancozeb (2.5 g/L) and Dimethomorph (1.0 g/L)+ Mancozeb (2.0 g/L) based on disease severity at 5th and 7th weeks after planting depending on the disease severity was found very effective in managing the disease.

Introduction

Cucumber, *Cucumis sativus* (L.) is one of the most preferred vegetables grown under protected conditions in the developed world. In India it is traditionally grown during January-March and September-December. *Pseudoperonospora cubensis* [(Berkeley & M. A. Curtis) Rostovzev], the causal agent of cucurbit downy mildew, is responsible for devastating losses worldwide of cucumber, cantaloupe, pumpkin, watermelon and squash (Elizabeth Savory *et al.*, 2011, Gisi and Sierotzki, 2008). According to Gisi (2002) almost 17% of the world fungicides market in 1996 was for agents used in downy mildew control. Effective control by planting resistant varieties is in many cases not possible and disease management problems have been compounded by the emergence of fungicide-resistant/tolerant variants of several oomycete pathogens (Gisi, 2002; Urban and Lebeda, 2006, 2007; Urban *et al.*, 2007).

Use of chemical fungicides leads to destruction of valuable beneficial microbes which in turn lead to increased vulnerability of crops and development of resistant strains of pathogens. Moreover, due to high input costs, crop failure by diseases results in heavy economic losses. Hence, precise disease management with emphasis on biocontrol is essential for assuring profitable farming in protected structures.

In this context, biocontrol approaches may help develop an eco-friendly control strategy for managing plant disease (Heydari & Misaghi 2003; Bharathi *et al.,* 2004; Shahraki *et al.,* 2008). Among biocontrol agents (BCA), antagonistic bacteria including *Pseudomonas* and *Bacillus* spp. have been shown to play very important roles in controlling several diseases. Therefore, the present study was undertaken to find out suitable biocontrol agents and comparatively safer fungicides to combat the disease.

Management of downy mildew in cucumber requires a multifaceted approach. At present no true resistant source of the cucumber is available in the country. Moreover, new fungicides and other molecules are introducing in the country every year against fungal diseases whose efficacy needs to be ascertained. As no true resistant cultivars are available at this moment, hence, chemical control is indispensable for alternative approach to manage these diseases. But

Materials and Methods

The field experiments for the efficacy of fungicides and biocontrol agents was conducted at, ICAR-Krishi Vigyan Kendra, Bengaluru Rural District (KVK, BRD) during *Rabi* 2015-16 and 2016-17 and ICAR-Krishi Vigyan Kendra, Chikkaballapur district during *Rabi* 2015-16 and 2016-17. The experiments were laid out in Randomized Block Design with three replications and seven treatments using cucumber hybrid Chithra. The soil of the experimental plot was red sandy loam in texture, low in available nitrogen (241 kg/ha), medium in available phosphorus (20.4 kg/ha) and available potassium (284 kg/ha). Normal recommended agronomic practices were adopted to grow the crop successfully in respect to application of fertilizer, irrigation and use of vegetable special. Two hand weeding was done at an interval of 25 days. The details of treatment combinations are given in Table 1.

Trichoderma viride and *Pseudomonas fluorescens* were mixed with FYM and allowed to multiply with proper moisture in it for 15 days. These were applied to field just before planting. Fungicide application treatments were done by power operated sprayer. Prophylactic spray of Mancozeb (0.25%) was given 3 weeks after sowing. Two sprays of systematic fungicides *viz*., Metalaxyl + Mancozeb (2.0 g /) and Dimethomorph (1.0 g /L)+ Mancozeb (2.0 g /L) were applied at regular intervals fifth and seventh weeks depending on the disease severity. Fungicidal solutions were prepared by dissolving definite amount of the chemicals in definite quantity of plain water. Spray was initiated just after the detection of downy mildew symptoms in the experimental area. Care was taken during spray for both the upper and lower surface of leaves. Spray tank was thoroughly washed before filling fungicidal solution materials. Vegetable Special, crop specific micronutrient technology developed by ICAR-IIHR was spayed to plants @3g/litre of water during flowering and fruiting stage. Data were taken on foliage infection. After harvesting yield per hectare was computed.

Statistical analysis

The disease severity data was arcsine transformed before analysis of variance (ANOVA). Recorded data were subjected to statistical analysis using ANOVA of SAS statistical data analysis software. Duncan's multiple range tests was used to determine the most significant treatment.

Results and Discussion

The data on per cent disease severity of downy mildew was recorded periodically from 20 to 60 days after sowing with an interval of 10

days (Table 2, 3, 4 and 5). Data on disease severity showed that biocontrol agents and fungicide tested reduced the disease intensity significantly compared to control. All the treatments showed different level of reaction to downy mildew of cucumber compared to control. The least per cent disease severity was recorded in T_4 treatment (7.42%) compared to check plot (24.98%) during Rabi 2015-16 in experimental plot of ICAR - Krishi Vigyan Kendra, Bengaluru Rural District. There were significant differences within treatments on yield at study location. All treatments were exceeds the control plots. The maximum yield (34.46 tons/ha) was recorded from T_4 treatment compared to check plot (28.10 t/ha). In Chikkaballapur district during Rabi 2015-16 the disease severity of 7.58% was recorded in T_4 treatment compared to check plot (24.98%). An yield of 34.16 t/ha was recorded form T_4 treatment compared to check plot (28.65 t/ha).

Similarly during Rabi *2016*- 17 in experimental plot of ICAR - Krishi Vigyan Kendra, Bengaluru Rural District the least disease severity was observed in T4 treatment (6.55%) compared to check plot (22.47). Maximum yield was recorded in T_4 treatment (33.76 t/ha) compared to check plot (27.50 t/ha). The least disease severity was recorded in T_4 treatment (7.42%) compared to check plot (21.93%). Maximum yield was obtained in T_4 treatment (34.16 t/ha) compared to check plot (27.85 t/ha) during Rabi 2016-17 in Chikkaballapur district.

Mancozeb as effective fungicide for the management of late blight and maximum fruit yield was reported by several workers (Sobolewski and Robak, 2004 and Chourasiya *et al.,* 2013).

Results of the present study showed that all fungicide treatments significantly controlled the downy mildew infection on cucumber as compared to check plot. Duarte *et al.,* (2007) have observed the positive effect from the combination of dimethomorph and Chlorothalonil succeeded by Metiram, compared to the combination of Metalaxyl and Chlorothalonil, succeeded by Metiram.

Table.1 Details of treatment combinations

Treatments	Details
T_1 –Farmer's practice	Indiscriminate spray of fungicides viz., Mancozeb (2.0 g /L), Fenamidone + Mancozeb (3.0 g /L), Chlorothalonil (2.0 g /L), Propineb (2.0 g /L), Cymoxanil+Mancozeb (3.0 g /L)
T_2–Recommended practice	Spray the crop with Metalaxyl + Mancozeb (2.0 g /L) and Cymoxanil+ Mancozeb (2.0 g /L)
T_3- Alternate practice -1	Seed treatment with Captan (2g/kg seeds), Spray of Mancozeb (2.0 g /L) &Cymoxanil+Mancozeb(2.0 g /L)
T_4- Alternate practice -2	*Trichoderma harzianum* enriched Farm Yard Manure (@ 1 kg / 100 kg FYM) application Seed treatment with Metalaxyl (2g/kg seeds) Prophylactic Spray with Mancozeb (2.50 g /L) followed by Spraying of Metalaxyl+ Mancozeb (2.0 g /) and Dimethomorph (1.0 g /L)+ Mancozeb (2.0 g /L)

Table.2 Percent disease severity and yield data of On Farm testing conducted on integrated management of downy mildew in cucumber during 2015-16 at Bengaluru Rural District

Demonstration number	Observations on Per cent Disease severity					Average per cent disease severity	Yield (t/ha)
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS		
T_1 (FP) (Check)	16.45 (23.93)	33.95 (35.63)	30.22 (33.34)	24.68 (29.77)	19.62 (26.28)	24.98 (29.79)	28.10
T_2 (RP)	14.30 (22.20)	30.20 (33.34)	26.10 (30.70)	21.22 (27.42)	17.82 (24.97)	21.93 (27.73)	29.07
T_3 (AP1)	16.25 (23.77)	28.02 (31.95)	22.62 (28.39)	15.29 (22.98)	11.46 (19.79)	18.73 (25.38)	30.06
T_4 (AP2)	6.17 (14.37)	12.67 (20.78)	7.81 (16.22)	6.26 (14.47)	4.19 (11.75)	7.42 (15.52)	34.46
SEm	0.34	0.73	0.59	0.46	0.32	0.49	1.00
CD (0.05)	1.12	2.39	1.92	1.51	1.03	1.59	3.25
CV	7.27	7.45	7.33	7.36	7.53	7.39	7.14

Table.3 Percent disease severity and yield data of On Farm testing conducted on integrated management of downy mildew in cucumber during 2016-17 at Bengaluru Rural District

Demonstration number	Observations on Per cent Disease severity					Average per cent disease severity	Yield (t/ha)
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS		
T_1 (FP) (Check)	17.10 (24.40)	30.66 (33.62)	26.79 (31.17)	21.30 (27.48)	16.50 (23.93)	22.47 (28.12)	27.50
T_2 (RP)	17.24 (24.53)	27.93 (31.90)	24.50 (29.66)	17.60 (24.80)	13.40 (21.47)	20.13 (26.47)	28.27
T_3 (AP1)	15.75 (23.38)	25.10 (30.01)	21.20 (27.40)	15.13 (22.87)	12.62 (20.80)	17.96 (24.89)	29.25
T_4 (AP2)	6.72 (14.98)	9.41 (17.73)	7.28 (15.65)	5.88 (14.01)	3.44 (10.68)	6.55 (14.61)	33.76
SEm	0.39	0.74	0.53	0.40	0.36	0.48	1.12
CD (0.05)	1.26	2.43	1.72	1.31	1.16	1.58	3.65
CV	6.54	7.99	6.70	6.98	8.11	7.26	8.22

Table.4 Percent disease severity and yield data of on Farm testing conducted on integrated management of downy mildew in cucumber during 2015-16 at Chikkaballapur District

Demonstration number	Observations on Per cent Disease severity					Average per cent disease severity	Yield (t/ha)
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS		
T_1(FP) (Check)	16.45 (23.93)	33.95 (35.63)	30.22 (33.34)	24.68 (29.77)	19.62 (26.28)	24.98 (29.79)	28.65
T_2 (RP)	15.17 (22.92)	28.31 (32.14)	24.50 (29.65)	19.60 (26.27)	14.12 (22.06)	20.34 (26.61)	29.97
T_3 (AP1)	10.95 (19.30)	25.10 (30.01)	20.07 (26.61)	16.62 (24.10)	10.15 (18.57)	16.58 (23.72)	30.64
T_4 (AP2)	5.47 (13.52)	13.47 (21.50)	9.20 (17.66)	5.86 (14.00)	3.91 (11.40)	7.58 (15.62)	35.06
SEm	0.34	0.73	0.59	0.46	0.32	0.49	0.95
CD (0.05)	1.12	2.39	1.92	1.51	1.03	1.59	3.09
CV	7.27	7.45	7.33	7.36	7.53	7.39	6.86

Table.5 Percent disease severity and yield data of On Farm testing conducted on integrated management of downy mildew in cucumber during 2016-17 at Chikkaballapur District

Demonstration number	Observations on Per cent Disease severity					Average per cent disease severity	Yield (t/ha)
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS		
T_1(FP) (Check)	14.30 (22.20)	30.20 (33.34)	26.10 (30.70)	21.22 (27.42)	17.82 (24.97)	21.93 (27.73)	27.85
T_2 (RP)	16.25 (23.77)	28.02 (31.95)	22.62 (28.39)	15.29 (22.98)	11.46 (19.79)	18.73 (25.38)	28.47
T_3 (AP1)	10.95 (19.30)	25.10 (30.01)	20.07 (26.61)	16.62 (24.10)	10.15 (18.57)	16.58 (23.72)	29.64
T_4 (AP2)	6.17 (14.37)	12.67 (20.78)	7.81 (16.22)	6.26 (14.47)	4.19 (11.75)	7.42 (15.52)	34.16
SEm	0.34	0.73	0.59	0.46	0.32	0.49	0.95
CD (0.05)	1.12	2.39	1.92	1.51	1.03	1.59	3.33
CV	7.27	7.45	7.33	7.36	7.53	7.39	7.37

Table.6 Pooled data of percent disease severity and yield data of OFT conducted on integrated management of downy mildew in cucumber at Bengaluru Rural District and Chikkaballapur district

Treatment details	Treatments	Average Per cent Disease Index								Pooled PDI	Pooled yield
		2014-15		2015-16		2014-15		2015-16			
		Bengaluru Rural				Chikkaballapur					
		PDI	Yield (t/ha)	PDI	Yield (t/ha)	PDI	Yield (t/ha)	PDI	Yield (t/ha)		
T_1	Farmers practice (Check)	24.98 (29.79)	28.10	22.47 (28.12)	27.50	24.98 (29.79)	28.65	21.93 (27.73)	27.85	23.59	28.03
T_2	Recommended practice	21.93 (27.73)	29.07	20.13 (26.47)	28.27	20.34 (26.61)	29.97	18.73 (25.38)	28.47	20.28	28.95
T_3	Alternate practice	18.73 (25.38)	30.06	17.96 (24.89)	29.25	16.58 (23.72)	30.64	16.58 (23.72)	29.64	17.46	29.90
T_4	Alternate practice 2	7.42 (15.52)	34.46	6.55 (14.61)	33.76	7.58 (15.62)	35.06	7.42 (15.52)	34.16	7.24	34.36
SEm		7.42 (15.52)	34.46	6.55 (14.61)	33.76	7.58 (15.62)	35.06	7.42 (15.52)	34.16	7.24	34.36
CD at 5%		0.49	1.00	0.48	1.12	0.49	0.95	0.49	0.95	0.49	1.01
CV		1.59	3.25	1.58	3.65	1.59	3.09	1.59	3.33	1.59	3.33

Table.7 Economics of treatments evaluated for the management of downy mildew in cucumber

Treatments	Yield (kg/ha)	Gross returns (Rs.8/kg)	Cost of cultivation/ha	Marginal cost (Rs.)	Total cost (Rs.)	B:C ratio (GR / TC)
T_1(Check)	28030	224240	85000	6950	91950	2.44
T_2(Recommended)	28950	231600	85824	3960	89784	2.58
T_3(Recommended)	29900	239200	87500	4350	91850	2.73
T_4(Evaluated)	34360	274880	85000	7100	92100	2.98

The efficacy of the tested bioagents against downy mildew may be due to nutrient competition, hyperparasitism, and/or antibiosis.

The pooled data (Table 6) indicated that, the average per cent disease severity was least in T_4 treatment (7.49%) compared to Check plot (23.59%). Maximum yield was recorded in T_4 treatment (34.36 t/ha) compared to check plot (28.03 t/ha).

From the pooled data of three season, it is evident that benefit: cost ratio of 2.98 was recorded in T_4 treatment and the least was noticed in check plot (2.44). A net income of Rs. 274880 /ha by investing Rs. 92100/ha was realized in T_4 treatment compared to check plot (Table 7). With respect to the economics of treatments evaluated for the management of late blight in potato the yield was highest in T_4 treatment (34.36 t/ha) compared to check plot (28.03 t/ha) (Table 7).

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