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Assessment on management of late blight in potato incited by *Phytophthora infestans*

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ABSTRACT :

Late blight incited by *Phytophthora infestans* is one of the most widely spread and economically important disease of potato. 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 viride* and *Pseudomonas fluorescens* 15 days before transplanting followed by prophylactic spray of Mancozeb (0.25%) 35 days after transplanting was found effective. Three sprays of fungicides *viz*., Fenamidone + Mancozeb (0.3%), Iprovalicarb + Propineb (0.3%) and Dimethomorph (0.1%) + Mancozeb (0.2%) sprayed at regular intervals of seventh, ninth and eleventh weeks depending on the disease severity was found very effective in managing the disease.

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INTRODUCTION

Potato (*Solanum tuberosum* L.) is an important solanaceous cash crop, used as staple food in many developing countries. In India, potato is the most important vegetable crop, grown on 1·83 million ha, with a total annual production of 3·73 million tonnes, respectively (Chowdappa *et al*., 2011). The crop is suffering from different biotic and abiotic factors. Among the biotic cause, the insect pests like aphid (*Myzuspersicae*, *Aphis gossypii*), cut worm (*Agrotisipsilon*), potato tuber moth (*Phthorimoea operculella*) and mole cricket (*Grylotalpa* spp.) are very common. Some of them act as vector of viral diseases of potato. Incidence of late blight (*Phytophthora infestans*), early blight (*Alternaria solani*), scab (*Streptomyces scabies*), wire stem (*Rhizoctonia solani*) and bacterial wilt (*Ralstonia solanacearum*) are most common and serious diseases causing huge yield loss every year. Among the diseases late blight of potato incited by *Phytophthora infestans* (Mont.) de Bary is the most destructive disease. Prior to 2006, late blight was an annual threat in the states of northern India, but it was not considered a major problem on potato production in South India. Although late blight has been known on potato in the Karnataka state of India

since 1953, serious epidemics have only been observed on tomato since 2008 (Chowdappa *et al*., 2013).

A huge amount of yield loss occurs due to late blight depending on degree of susceptibility of the cultivar, time of appearance, age of plant infection and other epidemiological factors (Nowicki *et al*., 2012 and Cooke *et al*., 2012). Several studies have demonstrated that severe epidemics of late blight were associated with the emergence of 'new' populations of *P. infestans*in which fungicide resistance or an ability to overcome host resistance had evolved (Lees *et al*, 2012). Management of late blight on potato requires a multifaceted approach. At present no true resistant source of the potato 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 indiscriminate use of chemical pesticides hampered ecological equilibrium, invites resurgence problems, develop resistance strains, destroy earth worms and other micro biota etc. Therefore, the present study was undertaken to find out suitable biocontrol agents and comparatively safer fungicides to combat the disease.

MATERIAL AND METHODS

The field experiments for the efficacy of fungicides and biocontrol agents was conducted at, Krishi Vigyan Kendra, Bengaluru rural (KVK BRD) during *Rabi* 2014-15 and 2015-16 and Krishi Vigyan Kendra, Chikkaballapur district during 2012-1 during *Rabi* 2014-15 and 2015 - 16. The experiments were laid out in Randomized Block Design with three replications and seven treatments using potato variety (cv. KUFRIJYOTI). The soil of the experimental plot was red sandy loam in texture, low in available nitrogen (156 kg/ha), medium in available phosphorus (12.5 kg/ha) and available potassium (165.5 kg/ha). Normal recommended agronomic practices were adopted to grow the crop successfully in respect to earthing- up, application of fertilizer and irrigation. Two hand weeding was done at an interval of 25 days. The details of treatment combinations are given in Table A.

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 Knapsack sprayer. Prophylactic spray of Mancozeb (0.2%) was given 35 days after transplanting. Three sprays of fungicides *viz*., Fenamidone + Mancozeb (0.3%), Iprovalicarb + Propineb (0.3%) and Dimethomorph (0.1%) + Mancozeb (0.2%) were applied at regular intervals seventh, ninth and eleventh weeks depending on the disease severity. Fungicidal solutions were prepared by dissolving definite amount of the chemicals in definitequantity of plain water. Spray was initiated just after the detection of late blight symptoms in the experimental area. Care was taken during spray both the upper and lower surfaceof leaves as well as stems was well covered by fungicidal solution. Spray tank was thoroughly washed beforefilling fungicidal solution materials. Data were taken on foliage infection, disease severity (1-9 scale), PDS(% disease severity) and yield. After harvesting tuber yield per hectare was computed based on total tuber yield per plot. Disease severity (1-9 scale) was as follows.

Table A : The details of treatment combinations

Treatments	Description
T_1	**Farmers practice (FP)** - Indiscriminate spray of fungicides *viz*., Mancozeb (2.0 g /L), Dimethomorph (1.0 g /L) + Mancozeb (2.0 g /L), Copper Oxy Chloride (3.0 g /L), Fenamidone + Mancozeb (3.0 g /L), Metalaxyl + Mancozeb (2.0 g /L), Cymoxanil + Mancozeb (3.0 g /L), Copper Hydroxide (2.0 g /L), Propineb (2.0 g /L), Chlorothalonil (2.0 g /L)
T_2	**Recommended practice (RP)** -Prophylactic – Mancozeb (2.0 g /L) – 2 sprays Metalaxyl + Mancozeb (2.0 g /L) Cymoxanil + Mancozeb (3.0 g /L)
T_3	**Alternate practice (AP)** - Soil application of Trichoderma harzianum and Pseudomonas fluorescens through farm yard manure (Enrichment- 1 kg / 100 kg for 15 days), tuber treatment with Mancozeb (2.0 g / L). Prophylactic spray – Mancozeb (2.5 g /L) – 5 weeks after planting followed by sprays of Fenamidone + Mancozeb (3.0 g/L), Iprovalicarb + Propineb (3.0 g/L) and Dimethomorph (1.0 g/L)+ Mancozeb (2.0 g/L)

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.

Score	% foliage affected	Description
1	0	None or very few lesions on the leaflets.
2	3	More than 0% but less than 10%.
3	10	More than 10% but less than 25%.
4	25	More than 25% but less than 50%.
5	50	Half of the foliage destroyed.
6	75	More than 50% but less than 75%.
7	90	More than 75% but less than 90%.
8	97	Only very few green areas leaf (much less 10%)
9	100	Foliage completely destroyed.

RESULTS AND DISCUSSION

The data on per cent disease severity of late blight was recorded periodically from 40 to 80 days after planting (DAP) with an interval of 10 days (Table 1, 2 and 3). 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 late blight of potato compared to control. The least per cent disease severity was recorded in T_3 and T_2 treatment with mean values of 6.72 per cent and 15.75 per cent, respectively during *Rabi* 2014-15 in experimental plot of Krishi Vigyan Kendra, Bengaluru rural (Table 1). Therefore, in comparisons, the highest per cent final disease severity (17.24%) was recorded from control plot. There were significant differences within treatments on yield at study location. All treatments were exceeds the control plots. The maximum yield (24.14 tons/ha) was recorded from

Table 1: Per cent disease severity and yield data of on farm testing conducted on integrated management of late blight in potato during *Rabi* 2014-15 at Bengaluru Rural district

Demonstration number	Observations on per cent disease severity					Average per cent disease severity	Yield (t/ha)
	40 DAP	50 DAP	60 DAP	70 DAP	80 DAP		
T_1 (FP)	17.24 (24.53)	27.93 (31.90)	24.50 (29.66)	17.60 (24.80)	13.40 (21.47)	20.13 (26.47)	18.69
T_2 (RP)	15.75 (23.38)	25.10 (30.01)	21.20 (27.40)	15.13 (22.87)	12.62 (20.80)	17.96 (24.89)	20.86
T_3 (AP)	6.72 (14.98)	9.41 (17.73)	7.28 (15.65)	5.88 (14.01)	3.44 (10.68)	6.55 (14.61)	24.14
S.E.±	0.39	0.74	0.53	0.40	0.36	0.48	0.21
C.D. (P=0.05)	1.26	2.43	1.72	1.31	1.16	1.58	0.48
CV	6.54	7.99	6.70	6.98	8.11	7.26	1.55

Table 2: Per cent disease severity and yield data of on farm testing conducted on integrated management of late blight in potato during *Rabi* 2015-16 at Bengaluru Rural district

Demonstration number	Observations on per cent disease severity					Average per cent disease severity	Yield (t/ha)
	40 DAP	50 DAP	60 DAP	70 DAP	80 DAP		
T_1 (FP)	17.10 (24.40)	30.66 (33.62)	26.79 (31.17)	21.30 (27.48)	16.50 (23.93)	22.47 (28.12)	17.88
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)	19.87
T_3 (AP)	8.14 (16.49)	10.92 (19.27)	8.25 (16.65)	6.16 (14.37)	3.63 (10.98)	7.42 (15.55)	23.84
S.E.±	0.52	0.80	0.68	0.55	0.46	0.60	0.41
C.D. (P=0.05)	1.70	2.60	2.20	1.79	1.50	1.96	0.94
CV	8.45	7.68	7.86	8.61	9.74	8.47	3.13

Table 3: Per cent disease severity and yield data of on farm testing conducted on integrated management of late blight in potato during *Rabi* 2014-15 at Chikkaballapur district

Demonstration number	Observations on per cent disease severity					Average per cent disease severity	Yield (t/ha)
	40 DAP	50 DAP	60 DAP	70 DAP	80 DAP		
T_1 (FP)	15.17 (22.92)	28.31 (32.14)	24.50 (29.65)	19.60 (26.27)	14.12 (22.06)	20.34 (26.61)	19.01
T_2 (RP)	10.95 (19.30)	25.10 (30.01)	20.07 (26.61)	16.62 (24.10)	10.15 (18.57)	16.58 (23.72)	21.19
T_3 (AP)	5.47 (13.52)	13.47 (21.50)	9.20 (17.66)	5.86 (14.00)	3.91 (11.40)	7.58 (15.62)	24.95
S.E.±	0.34	0.73	0.59	0.46	0.32	0.49	0.20
C.D. (P=0.05)	1.12	2.39	1.92	1.51	1.03	1.59	0.46
CV	7.27	7.45	7.33	7.36	7.53	7.39	1.44

T_3 treatment compared to check plot (20.86 t/ha). During *Rabi* 2015-16 the least disease severity was recorded in T_2 and T_3 treatments (8.54% and 16.25%), respectively compared to control (17.10%) (Table 2). An yield of 23.84 t/ha was recorded from T_3 treatment compared to check plot (17.88 t/ha). Similarly during *Rabi* 2014- 15 in experimental plot of Krishi Vigyan Kendra, Chikkaballapur district the least disease severity was recorded in T_2 and T_3 treatments (5.47% and 10.95%), respectively compared to control (15.17%) (Table 3). Maximum yield was obtained in T_3 treatment (24.95 t/ha) compared to check plot (19.01 t/ha).

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 late blight infection on tomato as compared to control.

Capriotti *et al*. (2005) reported the use of cabriotop- a combination product of pyraclostrobin+metiram was effective for both early blight and late blight. 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.

The pooled data (Table 4) indicated that, the average per cent disease severity was 21.98 per cent and 18.80

Table 4: Per cent disease severity and yield data of on farm testing conducted on integrated management of late blight in potato during *Rabi* 2015-16 at Chikkaballapur district

Demonstration number	Observations on per cent disease severity					Average per cent disease severity	Yield (t/ha)
	40 DAP	50 DAP	60 DAP	70 DAP	80 DAP		
T_1 (FP)	16.45 (23.93)	33.95 (35.63)	30.22 (33.34)	24.68 (29.77)	19.62 (26.28)	24.98 (29.79)	19.01
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)	21.39
T_3 (AP)	6.17 (14.37)	12.67 (20.78)	7.81 (16.22)	6.26 (14.47)	4.19 (11.75)	7.42 (15.52)	24.92
S.E.±	0.41	0.93	0.72	0.62	0.55	0.65	0.16
C.D. (P=0.05)	1.34	3.05	2.34	2.03	1.79	2.11	0.37
CV	7.44	8.16	7.50	8.00	8.85	7.99	1.16

Table 5: Pooled data of per cent disease severity and yield data of on farm testing conducted on integrated management of late blight in potato at Bengaluru Rural 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	20.13 (26.47)	18.69	22.47 (28.12)	17.88	20.34 (26.61)	19.01	24.98 (29.79)	19.01	21.98 (27.75)	18.65
T_2	Recommended practice	17.96 (24.89)	20.86	18.73 (25.38)	19.87	16.58 (23.72)	21.19	21.93 (27.73)	21.39	18.80 (25.43)	20.83
T_3	Alternate practice	6.55 (14.61)	24.14	7.42 (15.55)	23.84	7.58 (15.62)	24.95	7.42 (15.52)	24.92	7.24 (15.33)	24.46
S.E.±		0.48	0.21	0.60	0.41	0.49	0.20	0.65	0.16	0.56	0.25
C.D. (P=0.05)		1.58	0.48	1.96	0.94	1.59	0.46	2.11	0.37	1.81	0.56
CV		7.26	1.55	8.47	3.13	7.39	1.44	7.99	1.16	7.78	2.33

Table 6: Economics of treatments evaluated for the management of Late blight in potato

Treatments	Yield (kg/ha)	Gross returns (Rs.21/kg)	Cost of cultivation/ha	Marginal cost (Rs.)	Total cost (Rs.)	B:C ratio (GR/TC)
T_1 (Control)	18650	223800.00	115824.00	20960.00	136784.00	1.64
T_2 (Recommended)	20830	249960.00	105000.00	8350.00	113350.00	2.20
T_3 (Evaluated)	24460	293520.00	107032.00	10610.00	117642.00	2.49

per cent, respectively in T_3 and T_2 treatments whereas the per cent disease severity of 7.24 per cent was recorded in T_1 treatment. The pooled data revealed that the yield was highest in T_3 treatment (24.46 t/ha) and the least yield was recorded in control (18.65 t/ha) (Table 4).

From the pooled data of three season, it is evident that benefit: cost ratio of 2.62 was recorded in T_3 treatment and the least was noticed in control plot (1.73) A net income of Rs. 293520 /ha by investing Rs. 111642 /ha was realized in T_3 treatment compared to control (Table 5).

With respect to the economics of treatments evaluated for the management of late blight in potato the yield was highest in T_3 treatment (24.46 t/ha) and the least was recorded in T_1 treatment (18.65t/ha) (Table 6). The gross returns was highest in T_3 treatment (2.94 lakhs/ha) and the least was in T_1 treatment (2.23laks/ha). The total cost incurred in T_3 treatment was 1.17 lakhs/ha and in T_1 treatment was 1.36 lakhs/ha. From the pooled data, it is evident that benefit: cost ratio of 2.49 was recorded in T_3 treatment and the least was noticed in control plot (1.64).

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