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Management of Early Blight of Potato by using Newer Fungicides

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ABSTRACT: Management of early blight of potato caused by *Alternaria solani* experiment was conducted under *in- vitro* and *in- vivo* conditions at College of Horticulture, Bengaluru, and Horticulture Reasearch and Extenstion Centre, Hassan. The contact fungicides such as mancozeb-75% WP, zineb-75% WP, chlorothalonil-75% WP and systemic fungicides like hexaconazole- 5% EC, difenconazole-25% EC, tebuconazole- 25% EC were used at the concentration of 100, 250, 500 and 1000 ppm. Besides combi-products like carbendazim- 25% + mancozeb- 50% WS, tricyclazole-18% + mancozeb-62% WS, captan-70% + hexaconazole-5% WP and zineb- 78% + hexaconazole-4% were used at 500, 1000 and 1500 ppm, respectively along with a control. The same fungicides were taken for the field evaluation at recommended dose of concentrations. The results revealed that under *in- vitro* evaluation fungicides such as hexaconazole-5% EC, tebuconazole-25% EC, difenoconazole-25% EC, zineb-68% + hexaconazole-4% WP and captan-68% + hexaconazole-5% WP were found to be equally effective and significantly superior with 100 per cent inhibition at all the concentrations, which were on par with mancozeb (100 %) inhibition at 1000 ppm concentrations. At field evaluation, the best treatment was found that zineb-68% + hexaconazole-4% WP fungicide with least per cent disease index (PDI) of 15.11 followed by hexaconazole 5% EC (17.55%) at 65 days after planting.

Keywords: Management, Early blight, *In- vitro*, *In- vivo*, Fungicides, Evaluation.

INTRODUCTION

Potato (*Solanum tuberosum* L.) belongs to the family solanaceae is the most important crop among the vegetables. The crop stands prime position in the economy of poor, marginal farmers and plays a vital role in nutritional security by producing more bio-mass per unit area as compared to wheat, rice and maize in a short period of time. Potato is considered as "The King" of staple foods and is the only non-cereal food crop to command such a high position in the world. Potato is a rich source of calories and about 100 grams fresh weight of potato tuber yields 97 kilo calories, which is much higher than cereals. Potato is a good source of other nutrients like carbohydrates 20.60 per cent, protein 2.10 per cent, fat 0.30 per cent, 1.10 per cent crude fiber and 0.90 per cent ash. It also contains good amount of essential amino acids like leucine, tryptophan and isoleucine (Yadav and Srivastava 2014). Potato being a short duration crop gave ample and economical tuber yield in 80 to 90 days. In India potato is grown over an area of 2176 ha ('000 Ha) with the production of 49344 MT ('000 MT) and an average national yield per hectare is 23.00 tonnes in India (Anon., 2017). An area under potato cultivation in Karnataka is 44,000 hectares and total production of 6.98 lakh tonnes with the productivity of 13.74 tonnes per hectare.

Potato production is currently threatened by a number of biotic and abiotic factors. Among the biotic stresses, fungal diseases like late blight (*Phytophthora infestans*), early blight (*Alternaria solani*), powdery scab (*Spongospora subterranea*), wart (*Synchytrium endobioticum*), silver scurf (*Helminthosporium solani*), pink rot (*Phytophthora erythroseptica*), dry rot (*Fusarium* spp.), black scurf (*Rhizoctonia solani*) and charcoal rot (*Macrophomina phaseolina)* were the most destructive fungal diseases, which reduces the quality, quantity and market value of potato tubers (Abbas *et al*., 2013).

Among the fungal diseases, early blight is one of the most destructive disease of potato. The disease can damage both potato foliage and tubers and in turn cause yield loss up to 5 to 50 per cent. An early blight disease is prevalent across worldwide, wherever potatoes, tomatoes, peppers and egg plants are grown. Early blight is a polycyclic disease that can cause more than one disease epidemics within a single cropping season (Tsedaley, 2014). An early blight of potato is caused by two pathogens *viz*., *Alternaria solani* and *Alternaria alternata* but in some areas only *A. solani* is considered as the causative organism of this disease, with their

spores in abundance in the atmosphere (Iglesias *et al*., 2007) and in the soil. There is always a threat when conditions become conducive for infection and thus represents a serious threat to potato production (Leiminger and Housladen 2012).

Depending upon the varieties grown, weather conditions and inoculum load in the soil, this disease can causes an average annual yield loss of approximately 79 per cent of the total production of potato (Yadav *et al*., 2017). For effective management of this disease in early stage of crop growth, there is a need of suitable management approaches in order to reduce the disease severity with increased tuber yield. Therefore, by considering the above factors the present investigation was taken for the management of early blight of potato by using newer fungicides.

MATERIALS AND METHODS

An efficacy of contact, systemic and combi-product fungicides were evaluated under *in vitro* by poison food technique method. The pathogen *A. solani* was grown on PDA medium in petri plates for ten days prior to setting up of the experiment. The PDA media was prepared, melted and fungicidal suspension was added to the medium to obtain the desired concentration on the basis of active ingredient present in the chemical. Twenty ml of poisoned medium was poured in each of the sterilized Petri plates. The mycelial disc of 5.00 mm was taken from the periphery of ten days old culture and was placed at the center and incubated at 27±1°C till growth of the fungus touched the periphery in control plate. A suitable check was also maintained without addition of any fungicide and three replications were maintained for each treatment. The diameter of the colony was measured in two directions and average was worked out. The per cent inhibition of growth was calculated by using the formula given by Vincent (1947).

$$I = \frac{(C - T)}{C} \times 100$$

Where,

I= Per cent inhibition of mycelium

C= Growth of mycelium in control

T= Growth of mycelium in treatment

The following fungicides were tested

Treatments	Contact fungicides	Trade name	Concentration (ppm)			
T1	Mancozeb- 75% WP	Indofil M-45	100	250	500	1000
T2	Zineb- 75% WP	Indofil Z-78	100	250	500	1000
T3	Chlorothalonil- 75%WP	Kavach	100	250	500	1000
	Systemic fungicides					
T4	Hexaconazole- 5% EC	Contaf	100	250	500	1000
T5	Difenoconazole-25%EC	Score	100	250	500	1000
T6	Tebuconazole- 25% EC	Folicur	100	250	500	1000

Treatments	Combi-products of fungicides	Trade name	Concentration (ppm)		
T7	Carbendazim- 25% + Mancozeb- 50% WS	Sprint	500	1000	1500
T8	Tricyclazole-18% + Mancozeb-62%	Merger	500	1000	1500
T9	Captan-70% + Hexaconazole-5% WP	Taqat	500	1000	1500
T10	Zineb- 78% + Hexaconazole-4%	Avtar	500	1000	1500
T11	Control	No fungicides			

Management of early blight disease in potato experiment was conducted at Horticulture Research and Extension Station, Hassan during *Rabi* season 2018-19. An experiment was laid out in Randomized Completely Block Design (RCBD) with three replications. Potato seed tubers were planted on 7th January 2019 and harvesting was done on 6th March 2019. Three sprays of the fungicides were given at 15 days interval. The first spray was given immediately after the first appearance of early blight symptoms i.e. was on 35th days after planting. 2nd spray was given at 50th days after planting and 3rd spray was at 65th days after planting. The disease was scored by selecting five plants randomly in each plot and the data was converted into per cent disease index (PDI). Finally tuber yield data was recorded after harvest and benefit cost ratios were calculated.

Treatments used for field evaluation against early blight disease.

Tr. No.	Treatments details	Concentration (%)
T1	Mancozeb-75% WP	0.3
T2	Zineb-75%WP	0.3
T3	Chlorothalonil-75% WP	0.2
T4	Hexaconazole-5% EC	0.1
T5	Difenoconazole-25% EC	0.1
T6	Tebuconazole- 25% EC	0.1
T7	Carbendazim-25% + Mancozeb-50% WS	0.2
T8	Captan-70% + Hexaconazole-5% WP	0.2
T9	Tricyclazole-18% + Mancozeb-62% WP	0.2
T10	Zineb-68% + Hexaconazole-4% WP	0.2
T11	Control	

RESULTS AND DISCUSSION

In case of *in-vitro* evaluation of fungicides, the mancozeb-75% WP gave 100 per cent inhibition of the pathogen at 1000 ppm concentration. The chrolothalonil-75% WP and zineb-75%WP were revealed the least per cent inhibition of *Alternaria solani* at all the concentrations tested. Among all the systemic fungicides, hexaconazole-5% EC, difenoconazole-25 % EC and tebuconazole-25% EC were found 100 per cent inhibition at all the concentrations. Whereas, in combi-product fungicides zineb-68% + hexaconzole-4% WP and captan-70% + hexaconazole-5% WP were revealed 100 per cent inhibition of *Alternaria solani* at all the concentrations tested. Whereas, least inhibition was observed in carbendazim-25% + mancozeb-50% WS at all the concentrations (Table 1 & Fig. 1). However, least effective chemical was found to be chlorothalonil-75% WP at all the concentrations tested. At higher concentration of chlorothalonil-75% WP (1000 ppm) the inhibition recorded was 56.06 per cent followed by zineb (73.48%) at 1000 ppm concentration.

The same results were supported by the studies of (Sukrutha and Kamanna 2014) reported that hexaconazole-9%, tebuconazole-7% and combi products zineb-68% + hexaconazole-4% and captan-70% + hexaconazole-5% were equally found effective and significantly superior with 100 per cent inhibition at all the concentrations. Kumar and Barnwal (2016) observed that lowest colony diameter (5.0 mm) of *A. solani* was recorded in treatment having tricyclazole+ hexaconazole, tabuconazole + trifloxystrobin and hexaconazole + zineb-75% WP and showed inhibition over control of 94.40 per cent. (Sarfraz, *et al*., 2018) revealed that under *in-vitro* conditions fungicides such as difenoconazole-25% EC and difenoconazole + propiconazole at all concentrations showed best growth inhibition of *A. solani.*

Management of early blight disease in potato. The data revealed that zineb-68% + hexaconazole-4% WP having least Per cent Disease Index (PDI) of 15.11 per cent followed by hexaconazole-5% EC (17.55 %), which was on par with tebuconazole-25% EC (18.56) and difenoconazole-25% EC (18.98) at 65 DAP. Whereas, maximum per cent disease index of 53.33 per cent was noticed in control treatment (Table 2, Fig. 2 and Plate. 1).

The similar results obtained by Agha *et al*. (2016) reported that highest reduction was achieved with the fungicide difenoconazole, where disease severity reduced by 25.00 to 37.80 per cent and disease incidence reduced by 36.30 to 42.90 per cent compared to control. (More *et al*., 2016) observed that hexaconazole-5 EC (0.05%) @ 0.5 ml per l of water at 10 days interval was found significantly superior in controlling the early blight of potato with highest yield (18.10 t/ha). (Kumar and Barnwal 2016) in field trial study, lowest disease severity of 12.00 per cent was recorded after three sprays of hexaconazole-4% + zineb-68% WP (0.1%).

The cost economics for the management of early blight of potato, the data showed that highest potato tuber yield (18.88 t/ha) was obtained in zineb 68% + hexaconazole 4% WP treatment with benefit cost ratio of 3.75, which was on par with hexaconazole 5% EC (17.85 t/ha) and difenoconazole 25% EC (16.66 t/ha) with benefit cost ratio of 3.46 and 3.31, respectively. Further, tebuconazole 25% EC (16.00 t/ha) obtained with incremental benefit cost ratio of 3.16 and captan-70% + hexaconazole-5% WP (15.54 t/ha) with benefit cost ratio of 2.44 (Fig. 3). Therefore these fungicides can be recommended for the farmers for efficient management of early blight of potato.

Table 1*: In vitro* evaluation of fungicides against *Alternaria solani.*

Contact fungicides	**Concentration (ppm)**				
	100	**250**	**500**	**1000**	**Mean**
Mancozeb75%WP	16.29(4.05)*	32.19(5.70)*	55.68(7.48)	100(10.02)	51.04(6.81)
Zineb-75% WP	19.31(4.43)*	33.71(5.80)*	58.33(7.40)	73.48(8.51)	46.21(6.53)
Chlorothalonil75% WP	27.20(5.25)*	46.97(6.88)*	40.53(6.39)	56.06(7.52)	42.69(6.51)
Systemic fungicides					
Hexaconazole5% EC	100(10.02)*	100(10.02)*	100(10.02)	100(10.02)	100(10.02)
Difenconazole25% EC	100(10.02)*	100(10.02)*	100(10.02)	100(10.02)	100(10.02)
Tebuconazole25% EC	100(10.02)*	100(10.02)*	100(10.02)	100(10.02)	100(10.02)
SEM ±	1.804				
CD 0.01%	7.596226				
Combi-products	**Concentration (ppm)**				
	500	**1000**	**1500**		**Mean**
Tricyclazole18% + Mancozeb62% WP	47.73(6.94)*	62.88(7.96)*	66.67(8.20)*		58.09(5.77)*
Carbendazim 25% + Mancozeb50% WS	53.79(7.36)	66.29(8.17)	84.09(9.20)		68.05(6.18)
Captan70% + Hexaconazole5% WP	100(10.02)	100(10.02)	100(10.02)		100(10.02)
Zineb68% Hexaconazole4% WP	100(10.02)	100(10.02)	100(10.02)		100(10.02)
Control(No fungicide)	0(0.70)	0(0.70)	0(0.70)		0(0.70)
SEM ±	1.26				
CD at 1%	5.63				

*= Square root transformed values

Table 2: Management of early blight disease in potato by using newer fungicides.

Treatments	Fungicides	Concentration (%)	Per cent Disease Index (PDI)				Marketable tuber yield (t/ha)
			Before 1st spray (35 DAP)	After 1st spray (45 DAP)	After 2nd spray (55 DAP)	After 3rd Spray (65 DAP)	
T_1	Mancozeb-75% WP	0.3	18.25 (25.29)*	32.12 (34.52)	30.58 (33.57)	35.44 (36.53)	11.89
T_2	Zineb-75% WP	0.3	14.12 (22.07) *	23.54 (29.04)	24.56 (29.71)	27.2 (31.43)	13.60
T_3	Chlorothalonil-75% WP	0.2	17.56 (24.77) *	30.54 (33.54)	29.88 (33.14)	32.33 (34.65)	11.59
T_4	Hexaconazole-5% EC	0.1	23 (25.66) *	30.88 (33.76)	26.53 (31.00)	17.55 (24.76)	17.85
T_5	Difenconaxole-25% EC	0.1	15.69 (23.33) *	29.63 (32.98)	25.32 (30.21)	18.96 (25.81)	16.66
T_6	Tebuconazole- 25% EC	0.1	18.98 (25.83) *	25.64 (30.42)	20.55 (26.96)	18.58 (25.53)	16
T_7	Carbendazim-25% + Mancozeb-50% WS	0.2	17.89 (25.02) *	27.77 (31.80)	23.58 (29.05)	29.33 (32.79)	12.50
T_8	Captan-70% + Hexaconazole-5% WP	0.2	15.55 (23.22) *	25.58 (30.38)	27.58 (31.68)	22.5 (28.32)	15.54
T_9	Tricyclazole-18% + Mancozeb-62% WP	0.2	19.11 (25.92) *	25.15 (30.10)	19.55 (26.24)	23.55 (29.03)	12.23
T_{10}	Zineb-68% +Hexaconazole-4% WP	0.2	16.87 (24.25) *	24.55 (29.07)	20.15 (26.67)	15.11 (22.87)	18.88
T_{11}	Control	No fungicides	19.81 (26.43)	35.19 (36.38)	49.63 (44.79)	53.33 (46.91)	9.20
S.Em±			2.55	2.8	3.4	3.4	
CD 5%			7.38	8.27	10.23	10.04	

*=Arcsine transformed values; DAP: Days After Planting

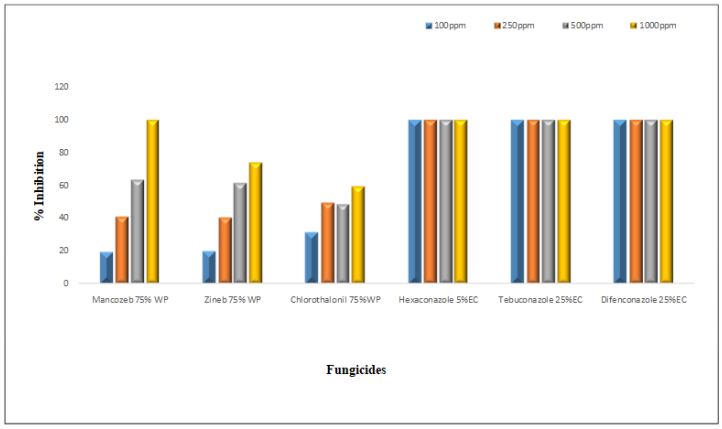

Fig. 1. *In-vitro* evaluation of contact and systemic fungicides against *Alternaria solani.*

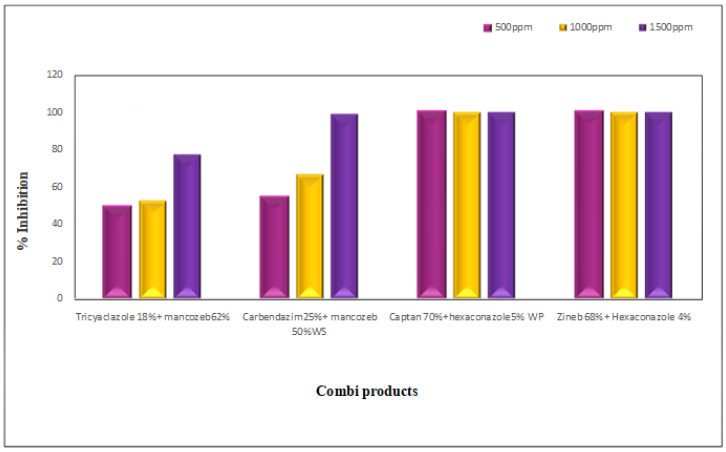

Fig. 2. *In vitro* evaluation of combi-products fungicides against *Alternaria solani.*

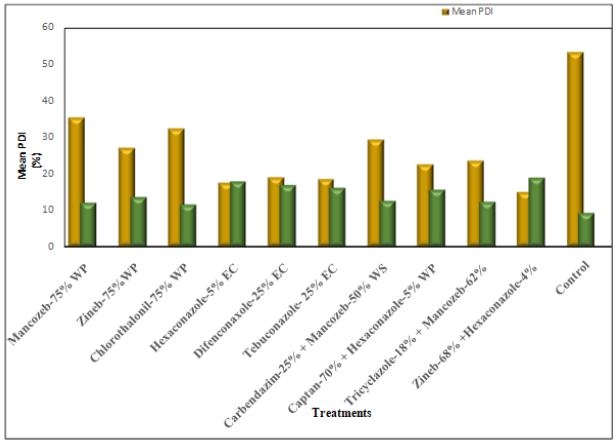

Fig. 3. Cost economics for the management of early blight of potato.

1.a. General view of field evaluation of fungicides

1. b. Zineb 68 % + Hexaconazole 4% WP

1. c. Hexaconazole 5%EC

1. d. Captan 70% + Hexaconazole 5% WP

Plate 1. Evaluation of newer fungicides against early blight disease of potato.

CONCLUSIONS

Among ten different fungicides tested under *in-vitro*, hexaconazole-5% EC, tebuconazole-25% EC, difenoconazole-25% EC, zineb-68% + hexaconazole-4% WP and captan-68% + hexaconazole-5% WP were found equally effective and significantly superior at all the concentrations with 100 per cent inhibition, which were on par with mancozeb-75% WP with inhibition (100%) at 1000 ppm concentration.

At field evaluation, best fungicides were found that zineb-68% + hexaconazole-4% WP with record of least per cent disease index of (15.11%) followed by hexaconazole-5% EC (17.55%), which was on par with tebuconazole-25% EC (18.58) and difenoconazole-25% EC (18.96 t/ha) at 65 DAP. Whereas, highest tuber yield (18.88 t/ha) was found in zineb-68% + hexaconazole-4% WP, which was on par with hexaconazole-5% EC (17.85 t/ha) and difenoconazole-25% EC (16.66 t/ha), tebuconazole-25% EC (16.00 t/ha), captan-70% + hexaconazole-5% WP (15.54 t/ha). Hence these fungicides can be recommended to the farmers for the effective management of early blight disease on commercial cultivation of potato.

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