The Bioscan 11(4): 2751-2756, 2016 (Supplement on Plant Pathology)
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.com

EVALUATION OF NEW FUNGICIDES FOR MANAGEMENT OF EARLY BLIGHT OF TOMATO

T. RAMESH KUMAR AND M. K. BARNWAL
Birsa Agricultural University, Ranchi-6, Jharkhand
e-mail : rameshkumartheerdhala@gmail.com

KEYWORDS
Lycopersicon esculentum
Alternaria solani
management

Received on :
07.06.2016

Accepted on :
07.10.2016

***Corresponding author**

ABSTRACT
The present studies were conducted to test the efficacy of some non-systemic, systemic and combi fungicides like Dithane M-45, Contaf Plus, Tilt, Bavistin and ICF110, Merger, Saaf, Nativo, Avtar against early blight of tomato cultivar S-22. A variant with no application of fungicide was used as a control. In laboratory condition lowest colony diameter (5.0 mm) of *A. solani* was recorded in treatment having Tricyclazole + Hexaconazole (T_3), Tabuconazole + Trifloxystrobin (T_4) and Hexaconazole + Zineb (T_6). The above three treatments showed inhibition over control 94.4%. In field trial study, Lowest disease severity of 12.0% was recorded when three sprays of Hexaconazole 4% + Zineb 68% (0.1%) (Avtar) was given. This treatment also recorded decrease in disease over control of 70.1%, fruit infection % of 2.1%, fruit yield of 219.8 q/ha and increase in fruit yield over control of 35.6%. This treatment was followed by three sprays of Tricyclazole 18% + Mancozeb 62% (0.1%) (Merger) which recorded disease severity of 15.0%, fruit infection of 2.3%, fruit yield of 210.0 q/ha and increase in fruit yield over control of 30.0%. whereas, the control plots recorded disease severity and fruit infection of 40.2% and 10.3%, respectively and tomato yield of 161.5 q/ha.

INTRODUCTION

Tomato is second most important remunerable solanaceous vegetable crops after potato either for local consumption and exportation. It is native to South America and is widely cultivated in 140 countries of the world with an annual production of 16826000 metric tonnes (Anonymous 2011). High nutritive value and varied climatic adaptability made the tomato cultivation more popular. Area under tomato in the country is about 8.65 lakh hectares and it is about 10.2% of the total cropped land under vegetables. Annual production of tomato in India is 1, 68, 26,000 metric tonnes which is 11.5% of the total vegetable production and productivity of 19.5 metric tonnes per hectare (Kumar, 2011).

There has been a gradual increase in the area under tomato while the production has been fluctuating due to various diseases and insect pest damage. There are several diseases on tomato caused by fungi, bacteria, viruses, nematodes and abiotic factors (Balanchard, 1992; Gomaa, 2001; Abdel-Sayed, 2006 and Abada *et al.*, 2008). Among the fungal diseases, early blight caused by Alternaria solani (Ellis and Martin) Jones and Grout, is the most threatening one (El-Abyad *et al.*, 1993; Gomaa, 2001; Abdel-Sayed, 2006 and Abada *et al.*, 2008), which causes great reduction in the quantity and quality of fruit yield. It is an important disease of tropical and sub-tropical areas. It is now found on all continents of the world. It is a serious disease in warm and humid regions (Sherf and MacNab, 1986) and in semiarid areas where frequent and prolonged night dew (Rotem and Reichert, 1964) and high relative humidity (Lawrence *et al.*, 1996) occurs. The fungus causes disease in tomato, potato and eggplant. The causal organism is air borne and soil inhabiting cause disease on foliage (leaf blight), stem (collar rot) and fruit (fruit rot) and can result in severe damage during all stages of plant development (Foolad *et al.*, 2000) disseminated by fungal spores (Datar and Mayee, 1981). It is increasingly becoming a limiting factor for successful cultivation of tomato and causes yield losses varies from 15-100% (Sohi, 1984 and Mathur and Shekhawat, 1986). Tomato crop is damaged due to severe infection of *A. solani* every year in India. The disease severity was recorded up to 90% in Varanasi region by Pandey *et al.*, 2002.

Primary methods of controlling early blight include preventing long periods of wetness on the leaf surface, cultural scouting, sanitation, and development of the host plant resistance with the application of fungicides (Namanda *et al.*, 2004; Kirk *et al.*, 2005 and Kumar and Srivastava, 2013). Cultivation of resistant varieties is the ultimate control of this disease. Although heritable resistance has been reported for *A. solani* (Christ, 1991; Herriot *et al.*, 1986 and Holley *et al.*, 1983), the disease is still primarily managed by use of foliar fungicides. However frequent application of these fungicides over a period of time has led to the development of fungicidal resistance in *Alternaria* resulting in emergence of fungicidal resistant strains.

Regarding the management of early blight of tomato many workers had done lot of works based on the chemical control. Earlier workers reported application of fungicides is the most effective method of *Alternaria* blight control and found that Tetra methyl thiram disulphide (TMTD), Dithane M-45, Bavistin, Dithane Z-78, Difoltan, Blitox, Captafol and Bordeaux mixture effectively manage the disease fungicides (Verma and Verma, 2010). Ashour (2009) reported that fungicides were the most efficient in managing the natural infection of the early blight and resulted in producing the highest fruit yield

compared with antioxidants as well as the alternation between them. Mancozeb was also effective in reducing the disease intensity and increase the yield of tomato (Maheswari *et al*., 1991; Choulwar, 1992; Bassler and Hausladen, 2003; Arunakumara *et al*., 2010; Gondal *et al*., 2012 and Chourasiya *et al*., 2013). Patil *et al*. (2003) reported that carbendazim was best fungicides to minimize the disease incidence and highest fruit yield while according to Datar and Mayee (1985), Fentin hydroxide and mancozeb were superior for the controlling the disease. Kumar *et al*. (2007) reported that hexaconazole (0.05%) and azoxytrobin (0.2%) was very effective in managing early blight of tomato. These fungicides affect only one or perhaps two stapes in a genetically control events into the metabolism of the fungus. Therefore, the present investigation was carried out to evaluate new fungicides for management of early blight of tomato.

MATERIALS AND METHODS

The efficacy of one non-systemic fungicide, Mancozeb 45% (Dithane M-45), three systemic fungicides, Hexaconazole 5% (Contaf Plus), Propiconazole 25% (Tilt), Carbendazim 50% (Bavistin) and five combi fungicides *viz*., Tricyclazole 45% + Hexaconazole 10% (ICF110), Tricyclazole 18% + Mancozeb 62% (Merger), Carbendazim 12% +Mancozeb 63% (Saaf), Tabuconazole 50% + Trifloxystrobin 25% (Nativo), Hexaconazole 4% + Zineb 68% (Avtar) were tested against *Alternaria solani* for colony diameter on the potato dextrose agar media using poisoned food technique under *in vitro* and field condition.

Poisoned food technique

The poisoned food technique (Schmitz, 1930) was followed to evaluate the efficacy of non-systemic, systemic and combi products fungicides in inhibiting the mycelial growth of *A. solani*. The fungus was grown on PDA medium for eight days prior to setting up the experiment. The PDA medium was prepared and melted. The fungicide was added to the melted medium to obtain the required concentrations on commercial formulation basis of the fungicide. Fifty ml of poisoned medium was poured in each sterilized Petriplates. Suitable check was also maintained (only PDA) side by side. Mycelial disc of 5 mm was taken from the periphery of eight days old colony was placed in the centre of Petriplates and incubated at 27 $\pm 2^{o}$ C for eight days and three replications were maintained for each treatment in completely randomised design. The efficiency of various new fungicides was recorded by measuring the colony diameter of the *A. solani*. Per cent inhibition of mycelial growth of the fungus was calculated by using the formula by Vincent (1947)

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

Where, I = Per cent inhibition C = Radial growth in control, T = Radial growth in treatment (fungicide)

The field experiment was laid out at Research Farm of Department of Plant Pathology, Birsa Agricultural University, Ranchi-6, during *Rabi* season, 2013-14 in Randomised complete block design (RCBD). Twenty days old seedlings of most susceptible Var. S-22 were transplanted with a spacing of 60 cm X 45 cm. The plot size was 3.6 m X 3.15 m with three replications. The fertilizers N: P_2O_5: K_2O and FYM were applied @ of 100: 60: 60 Kg/ha and 25 t/ha, respectively. There were nine treatments including control. Thirty days after transplanting (DAT) plants were inoculated with the spore suspension of *A. solani* having $1X10^7$ spores per ml of sterilized distilled water. The spore suspension was sprayed in the evening to provide 12 hours of humid environment for easy establishment of the pathogen.

The first spray of fungicides was given two days after spraying of inoculum. Second spray was given 10 days after (DA) first spray and Third spray was given 10 DA second sprays of fungicides. Ten plants were selected randomly in each plot and observation on disease severity and per cent fruit infection was recorded ten days of last spray of fungicides by using 0-5 scale (Mayee and Datar, 1986).

Per cent disease index (PDI) was calculated by using following formula proposed by Wheeler (1969).

$$PDI = \frac{\text{Sum of the individual disease ratings}}{\text{Number of fruits/lesves observed x Maximum disease grade}} x100$$

The per cent disease control (PDC) over control was calculated as

$$PDC \text{ over control} = \frac{\text{PDI in control - PDI in treatment}}{\text{PDI in control}} x\,100$$

The fruit yield in each plot was recorded separately. Increase in fruit yield over control was also calculated.

RESULTS AND DISCUSSION

The lowest colony diameter of 5.0 mm was recorded in treatment having Tricyclazole + Hexaconazole (T_3), Tabuconazole + Trifloxystrobin (T_4), and Hexaconazole + Zineb (T_6). The above three treatments showed inhibition over control 94.4%. These treatments followed by Mancozeb (0.25%) which recorded 6.0 mm colony diameter of the pathogen and 93.3% inhibition over control. The next best treatments in order of superiority Tricyclazole + Mancozeb (colony diameter 7.6 mm), Hexaconazole (colony diameter 28.0 mm). The control plate showed colony diameter of 89.0 mm (Table 2 and Figure 1.).

In field trials, all the fungicides significantly reduced the disease severity in comparison to control. Lowest disease severity of 12.0% was recorded when three sprays of Hexaconazole 4% + Zineb 68% (0.1%) (Avtar) was given. This treatment also recorded decrease in disease over control of 70.1%, fruit infection % of 2.1%, fruit yield of 219.8 q/ha and increase in fruit yield over control of 35.6%. This treatment was followed by three sprays of Tricyclazole 18% + Mancozeb 62% (0.1%) (Merger) which recorded disease severity of 15.0%, decrease in disease over control of 62.7%, fruit infection of 2.3%, fruit yield of 210.0 q/ha and increase in fruit yield over control of 30.0%. The next best treatment was three sprays of Mancozeb 75% (0.25%) which recorded disease severity of 17.8%, decrease in disease over control of 55.7%, fruit infection of 3.2%, fruit yield of 198.8 q/ha and increase in yield over control of 23.1%, whereas, the control plots recorded disease

Table 1: Disease rating scale for the assessment of early blight of tomato

Scale	Description
0	No symptoms on the leaf, fruit
1	0-5% leaf area infected and covered by spot, no spot on petiole and branches, fruits
2	6-20% leaf area infected and covered by spot, some spots on petiole, branches, fruits
3	21-40% leaf area infected and covered by spot, spots also seen on petiole, branches, fruits
4	41-70% leaf area infected and covered by spot, spots also seen on petiole, braches, fruits
5	>71% leaf area infected and covered by spot, spots also seen on petiole, branches, fruits

Table 2: In vitro evaluation of fungicides against *A. solani* (Early blight of tomato)

	Treatments	Dose (%)	*Colony diameter of *A. solani* (mm)	Inhibition over control (%)
T_1	Hexaconazole 5%	0.1	28.0	68.5
T_2	Propiconazole 25 %	0.1	36.3	59.2
T_3	Tricyclazole 45% + Hexaconazole 10%	0.1	5.0	94.4
T_4	Tabuconazole 50% + Trifloxystrobin25%	0.05	5.0	94.4
T_5	Carbendazim 12% + Mancozeb 63%	0.2	83.0	6.7
T_6	Hexaconazole 4% + Zineb 68%	0.1	5.0	94.4
T_7	Tricyclazole 18% + Mancozeb 62%	0.1	7.6	91.5
T_8	Mancozeb	0.25	6.0	93.3
T_9	*Alternaria solani* (Control)	-	89.0	-
CD at 5%			2.7	
CV %			5.4	

*Mean of three replications

Table 3: Effect of fungicides for management of early blight of tomato under field condition

	Treatments	Dose(%)	*PDI (%)	*PDOC(%)	* Fruit infection (%)	*Fruit Yield(q/ha)	IYOC (%)
T_1	Hexaconazole 5% SC	0.1	21.4(27.5)	46.8	3.8 (11.2)	195.6	21.1
T_2	Tricyclazole 18% + Mancozeb 62% WP	0.1	15.0(27.3)	62.7	2.3(8.6)	210.0	30.0
T_3	Propiconazole 25% EC	0.1	27.3(31.4)	32.1	5.2(13.1)	179.6	10.8
T_4	Carbendazim 12% + Mancozeb 63% WP	0.2	23.3(28.8)	42.0	3.9(11.4)	190.0	17.6
T_5	Carbendazim 50% WP	0.1	34.3(35.8)	14.7	7.2(13.7)	173.9	7.6
T_6	Hexaconazole 4% + Zineb 68% WP	0.1	12.0(20.1)	70.1	2.1(8.3)	219.8	35.6
T_7	Mancozeb 75% WP	0.25	17.8(22.3)	55.7	3.2(10.3)	198.8	23.1
T_8	Tabuconazole 50% + Trifloxystrobin 25% WG	0.05	31.4(34.0)	21.9	6.8(15.1)	174.3	7.9
T_9	Control	-	40.2(39.3)	-	10.3(18.7)	161.5	-
	CD at 5%		4.4		2.6	24.3	
	CV %		8.6		12.0	7.4	

*Mean of three replication Figures in parentheses are transformed arc sine values; *PDOC – per cent decrease in disease over control * IYOC – Increase in yield over control

T_1-Contaf Plus, T_2-Tilt, T_3-ICF110, T_4-Nativo, T_5-Saaf, T_6-Avtar, T_7-Merger, T_8-Dithane M-45, T_9-*Alternaria solani* (Control)

Figure1 : In vitro evaluation of fungicides against *Alternaria solani*

severity and fruit infection of 40.2% and 10.3%, respectively and tomato yield of 161.5 q/ha. The fruit yield of best treatment *i.*e., three sprays of Hexaconazole 4% + Zineb 68% (0.1%) was at par with the treatments *i.*e., three sprays of Tricyclazole 18% + Mancozeb 62% (0.1%) and three sprays of Mancozeb 75 % (0.25%) and Hexaconazole 5% (0.1%) (Table 3).

Choulwar and Datar (1994) studied the tolerance of *A. solani* to fungicides like Mancozeb, Captofol, Thiophenate methyl and Carbendazim. These were tested at 1000, 1500, 2000, 2500 ppm *in vitro*. The results indicated that *A. solani* could tolerate 2500 ppm of all the fungicides tested.

Arunakumara (2006) observed copper Oxychloride and Mancozeb among contact fungicides at all tested concentrations were found to be highly effective in inhibiting the growth of *A. solani*. Among the systemic fungicides, Propiconazole and Metalaxyl MZ fungicides at all tested concentrations were found to be highly effective in inhibiting the growth of *A. solani*.

Sharma and Gaur (2009) evaluated nine fungicides against *A. alternata* under *in vitro* condition. Among the tested fungicides

Prochloraz (95.3%) was most effective in inhibiting mycelial growth followed by Propineb (65.8%), Saaf (60.5%) and Dithane M-45 (57.8%).

Issiakhem and Bouznad (2010) showed effectiveness of Difenoconazole on development of mycelial growth of *A. solani* and reported that Difénoconazole had a strong inhibition effect on *A. solani* (89%) with a concentration of 0.97 ppm and conidial germination also strongly reduced and reached 92% at 1.95 ppm.

Patel and Choudhary (2010) reported efficacy of foliar spray of contact fungicide Mancozeb 75WP (0.2%) against early blight tomato, gave maximum fruit yield (245.30q/ha). Among systemic fungicides, Difenconazole (0.1%) was effective in controlling the disease.

Nashwa (2011) conducted greenhouse experiments of fungicidal management against early blight of tomato caused by *A. solani*. The highest reduction of disease severity (82.8%) was achieved by fungicide (Ridomil plus 50% WP, 15% Metalaxy + 35% Copper oxychloride, at 2g/L). The greatest reduction of disease severity was achieved by Ridomil plus 74.2%.

Abdussamee *et al*. (2014) tested five fungicides against *A. solani*, *viz*., Cabriotop, Precure Combi, Halonil, Topsin-M and Difenoconazole were tested through poisoned food technique against *A. solani*. There was a significant decrease in mycelial growth of the fungus with an increase in fungicidal concentration. At 150 ppm, Difenoconazole (91.95%) gave maximum inhibition of the mycelial growth followed by Cabriotop (64.36%).

Dushyant *et al*. (2014) evaluated the efficacy of different fungicides against *Alternaria solani* at three different concentrations *viz*., 100, 200 and 300 ppm under laboratory condition. Minimum mycelia growth of *A. solani* was observed in Carbendazim + Mancozeb (8mm) followed by Mancozeb (10.33mm) and Iprodione + Carbendazim (12.67mm) at 300 ppm. Carbendazim + Mancozeb were found most effective among all tested fungicides. They also reported that minimum disease intensity (8.27%) was observed with Carbendazim + Mancozeb @ 0.2% concentration followed by with Mancozeb (0.2%) and Iprodione + Carbendazim (0.2%).

Nikam *et al*. (2014) conducted *In vitro* efficiency of systemic and non-systemic fungicides against *Alternaria solani*. Among systemic fungicides, Propiconazole and Penconazole were found most effective and both of which recorded highest average mycelial growth inhibition of 94.4 per cent. The second, third and fourth best fungicides found most effective were Hexaconazole (94.19%) and Diffenconazole (86.84%) and Benomyl(82.34%). Among non-systemic/ contact fungicides, Propineb and Taqat were found most effective and both of which recorded highest average mycelial growth inhibition of 91.30 per cent. This was followed by the fungicides *viz*., Curzate (75.93%), Copper hydroxide (75.31%), Mancozeb (72.83%), Ridomil MZ (67.66%) and Saff (66.55%).

Singh *et al*. (2001) noticed the best control of leaf blight disease of tomato caused by *A. solani* by 3 foliar sprays of Dithane M-45 (0.2%) at 15 days interval. The crop transplanted during 45th meteorological week (5th November) and sprayed with Mancozeb produced significantly higher yield of tomato.

Prasad and Naik (2003) tested the efficacy of non-systemic fungicides (Iprodione, Mancozeb and Copper oxychloride), systemic fungicides (Thiophenate-methyl, Triadimefon, Benomyl and Carbendazim), combi product (Saaf) in controlling the early blight of tomato. Mancozeb treatment gave the highest cost-benefit ratio of 1:11.4 in addition to reducing the disease incidence.

Tofoli *et al*. (2003) evaluated the effectiveness of various groups of fungicides for controlling early blight (*Alternaria solani*) as well as their effect on tomato fruit yield, following early blight severity in leaf lets and stems. The highest levels of disease control, quality and increase in fruit yields were obtained with Pyraclostrobin + Metiram, Fenamidone + Chlorothalonil, Famoxadone + Cymoxanil + Mancozeb, Kresoxim-methyl, Azoxystrobin, Difenconazole, Tebuconazole, Pyrimethanil, Cyprodinil, Famoxadone + Mancozeb followed by Prochloraz, Fluazinam, Procymidone, Iprodione, Mancozeb and Chlorothalonil.

Abhinandan *et al*. (2004) tested the efficacy of commercial fungicides (Dithane M-45) (Mancozeb) at 0.25%, Kavach (Chlorothalonil) at 0.25%, Rovral (Iprodione) at 0.20%, Blitox (Copper oxychloride) at 0.25%, Syllit (Dodine) at 0.3%, Antracol (Propineb) at 0.15%, Tilt (Propiconazole) at 0.05% and Topaz (Penconazole) at 0.05% in controlling the *Alternaria* leaf blight of tomato. Dithane M-45, followed by Kavach were found to be very effective in controlling the disease with >50 per cent disease control compared to the control treatment.

Kumar *et al*. (2007) reported that Hexaconzole (0.05%) and Azoxystrobin (0.2%) was very effective for the management of early blight disease of tomato and more beneficial and economic to the farmers.

Ilhe *et al*. (2008) tested the efficacy of Mancozeb 75 WP (0.25%) and Tebuconazole 25 EW (0.05%) in controlling the early blight and powdery mildew of tomato. Alternate sprays of both the chemicals found effective in controlling the disease with 71.08% disease control and also given better yield.

Kumar *et al*. (2010) reported the maximum disease control with lowest PDI was recorded in the Propiconazole (0.1%) treated plots followed by Pyraclostrobin (0.2%). However, least fruit infection was recorded in 0.1% Propiconazole sprayed plots (1.0%) followed by 0.2% Mancozeb (1.4%).

Patel and Choudhary (2010) reported efficacy of foliar spray of contact fungicide Mancozeb 75WP (0.2%) against early blight tomato, gave maximum fruit yield (245.30q/ha). Among systemic fungicides, Difenconazole (0.1%) was effective in controlling the disease.

Sali *et al*. (2010) reported that two sprays of Mancozeb (0.3%) or Propiconazole (0.05%) at an interval of 15 days are effective for reducing disease intensity of early blight of tomato.

Gangwar *et al*. (2012) found that Thiophanate- methyl and Chlorothalonil were most efficacious against the early blight of tomato under field condition. Thiophanate- methyl (1.5 g/ litre water) and Chlorothalonil (1.5 g/litre water) were found significantly superior than other treatments.

Gondal *et al*. (2012) conducted trials on effect of different doses of fungicide (Mancozeb) against early blight of tomato.

They found that weekly spray (4 sprays) of Mancozeb @ 12 g/ lit of water were cost effective and eco-friendly for management of early blight of tomato.

Jambhulkar *et al*. (2012) reported spray of Azoxystrobin 23% SC showed promising results by reducing disease severity by 38.9% as compare with control.

Chourasiya *et al*. (2013) evaluated the effect of certain fungicides against early blight of tomato caused by *Alternaria solani* (Ellis and Martin) under field condition. Lowest per cent disease incidence (PDI) was observed in Mancozeb (18.36) followed by Carbendazim (25.62). Similarly, the highest yield of tomato fruits was recorded with Mancozeb followed by Carbendazim. The highest cost benefit ratio was also obtained with Mancozeb treatment (1:4.15) followed by Carbendazim (1:3.73).

Sahu *et al*. (2013) conducted to test the efficacy of some newer molecules like Pyraclostrobin, Boscalid, and their combination Maccani, Pristine along with commonly used chemicals viz., Mancozeb, Copper oxychloride and Chlorothalonil against early blight of tomato. All fungicide treatments reduce the disease severity as compared to untreated check. Pristine 38%WG (31.88%) significantly reduced the disease followed by Maccani 16%WG (33.31%) and increase the yield from 33.50 tonnes/ha (Pristine 38%WG) and 32.44 tonnes/ha (Maccani 16%) as compared to a maximum disease (76.2%) and minimum yield of only 21.15 tonnes/ha in control.

Abdussamee *et al*. (2014) conducted a field trial for fungicidal management of early blight of tomato. Maximum disease control with PDI (11.84%) was recorded in the Difenoconazole treated plots followed by Cabriotop sprayed plots with PDI (26.66%).

Dushyant *et al*. (2014) were tested different fungicides against early blight of tomato. All the fungicides were found to be significantly superior over control in management of the disease. Minimum disease intensity (8.27%) was observed with Carbendazim + Mancozeb @0.2% conc. followed by with Mancozeb @0.2% (11.47%), Iprodione + Carbendazim @0.2% (15.2%).

Saha and Das (2015) conducted field trials for evaluation of fungicides for management of early blight of tomato. They found that Mancozeb (AUDPC: 96.84) showed minimum disease severity followed by Difenconazole (AUDPC: 98.44), Hexaconazole (AUDPC: 98.69) and Carbendazim (AUDPC: 97.68).

REFERENCES

Abada, K. A., Mostafa, S. H. and Hillal, M. R. 2008. Effect of some chemical salts on suppressing the infection by early blight disease of tomato. *Egypt. J. Appl. Sci*. **23(20):** 47-58.

Abdel-Sayed, M. H. F. 2006. Pathological, physiological and molecular variations among isolates of *Alternaria solani* the causal of tomato early blight disease. Ph. D. Thesis, Fac. Agric. Cairo Univ. p.181.

Abdussamee, H., Hussain, M., Mubasher Ali, M., Shahid, S., Sami Ullah, K. J., Shahbaz Talib Sahi and Hannan, A. 2014. Genetic response of tomato germplasm against early blight and its management through fungicides. *Applied Science Reports*.**2(3):** 119-127.

Abhinandan, D., Randhawa, H.S. and Sharma, R.C. 2004. Incidence of *Alternaria* leaf blight in tomato and efficacy of commercial fungicides for its control. *Ann. Biol*. **20:** 211-218.

Arunakumara, K. T., Kulkarni, M. S., Thammaiah, N. and Hegde, Y. 2010. Fungicidal management of early blight of tomato. *Indian Phytopath*. **63(1):** 96-97.

Arunakumara, K .T. 2006. Studies on *Alternaria solani* (Ellis and Martin) Jones and Grout causing early blilght of tomato. *M.Sc. thesis,* Univ. Agric. Sci., Dharwad, Karnataka, sIndia.

Ashour, A. M. A. 2009. A protocol suggested for managing tomato early blight. *Egypt. J. Phytopathol*. **37(1):** 9-20.

Balanchard, D. 1992. A colour atlas of tomato diseases. Wolfe Pub. Ltd., Brook House, London, p.298.

Basseler, A. K. and Hausladen, S. P. 2003. Effect of some fungicides on infection of tomato with leaf mold and early blight. *Arab J. PI. Prot*. **7(2):** 126-132.

Choulwar, A. B. and Datar, V. V. 1992. Management of tomato early blight with chemicals. *J. Maharashtra Agric. Uni.* **17:** 214-216.

Choulwar, A. B. and Datar, V.V. 1994. Tolerance of *Alternaria solani* to fungicides. *J. Maharashtra Agril. Univ*. **19(1):** 133-134.

Chourasiya, P. K., Abhilasha, A. L. and Sobita, S. 2013. Effect of certain fungicides and botanicals against early blight of tomato caused by *Alternaria solani* (Ellis and Martin) under Allahabad Uttar Pradesh, India conditions. *International J. of Agril. Sci. and Res.* **3:** 151-156.

Christ, B. J. 1991. Effect of disease assessment method on ranking potato cultivars for resistance to early blight. *Plant Disease*. **75:** 353-356.

Datar, V. V. and Mayee, C. D. 1981. Assessment of loss in tomato yield due to early blight, *Indian Phytopath*. **34:** 191-195.

Dushyant,Khatri, N. K. and Prasad, J. 2014. Efficacy of different fungicides against *Alternaria solani* of tomato *In vitro* and *In vivo*. *J. Mycol. Plant Pathol*.**44(3):** 227-392.

El-Abyad, M. S., El-Sayed, M. A., El-Shanshoury, A. R. and El-Abbagh, S. M. 1993. Towards the biocontrol of fungal and bacterial diseases of tomato using antagonistic Streptomyces spp. *Plant and Soil*. **149(2):** 185-195.

Foolad, M. R., Subbiah, P. and Lin, G. Y. 2000. Parent-offspring correlation estimates of heritability for early blight resistance in tomato. *Euphytica*. **126:** 291-297.

Gangwar, R. K., Singh, S. R. and Prajapati, R. K. 2012. Efficacy of different fungicides against *Alternaria* blight of tomato. *Indian Phytopath*. **65(3):** 115-148.

Gomaa, A. M. I. 2001. Pathological studies on early blight of tomato. M.Sc. *Thesis., Fac. Agric.*, Cairo Univ.

Gondal, A. S., ljaz, M., Riaz, K. and Khan, A. R. 2012. Effect of different doses of fungicide (mancozeb) against *Alternaria* leaf blight of tomato in tunnel. *J. Plant Pathol. Microb.* **3:** 125.

Herriot, A. B., Haynes, JrFL., and Shoemaker, P.B. 1986. The heritability of resistance to early blight in diploid potatoes (*Solanum tuberosum* subsp. *phureja* and *stenotonum*). *Am. Potato J.* **63:** 229-232.

Holley, J. D., Hall, R. and Hofstra, G. 1983. Identification of rate-reducing resistance to early blight in potato. *Can. J. Plant Pathol*. **5:** 111-114.

Ilhe, B. M., Shinde, H. N. Bhalekar, M. N. and Kshirsagar, D. B. 2008. Management of fungal diseases complex of tomato. *J. Plant Dis. Sci.* **3(2):** 173-175.

Issiakhem, F. and Bouznad, Z. 2010. *In-vitro* evaluation of Difenoconazole and Chlorothalonil on conidial germination and mycelial growth of *Alternaria alternata* and *A. solani,* causal agent of early blight of tomato in Algeria. Twelfth Euro Blight workshop Arras (France), PPO-special report no. **14:** 297-302.

Jambhulkar, P. P., Meghwal, M. L. and Kalyan, R. K. 2012. Efficacy of plastic mulching, marigold intercropping and fungicidal spray against early blight of tomato caused by *Alternaria solani*. *The Bioscan*. **7(2):** 365-368.

Kirk, W. W., Abu-El Salem, F. M., Muhinyuza, J. B., Hammerschmidt, R. and Douches, D. S. 2005. Evaluation of potato late blight management utilizing host plant resistance and reduced rates and frequencies of fungicide applications. *Crop Prot*. **24:** 961-970.

Kumar, Arun, K. T., Kulkarni, M. S., Thammaiah, N. and Yashoda, H. 2010. Fungicidal management of early blight of tomato. *Indian Phytopath*. **63(1):** 96-97.

Kumar, B. 2011. Indian Horticulture Database-2011. Ed. Mistry, N.C., Singh, B. and Gandhi, C.P. (www. nhb.gov.in)

Kumar, S. and Srivastava, K. 2013. Screening of tomato genotypes against early blight (*Alternaria solani*) under field condition. *The Bioscan*. **8(1):** 189-193.

Kumar, V., Gupta, R. C., Singh, P. C., Pandey, K. K., Kumar, R., Rai, A. S. and Rai, M. 2007. Management of early blight disease of tomato cv. 'Ksahi Amrit' through fungicides, bioagents and cultural practices in India. *Veg. Sci*. **34(2):** 206-207.

Lawrence, C. B., Joosten, M. H. A. and Tuzun, S. 1996. Differential induction of pathogenesis related protein in tomato by *Alternaria solani* and the association of a basic chitinase isozyme with resistance. *Physiological and Moleculer Plant Pathology*. **48:**361-377.

Maheswari, S. K., Gupta, P. C. and Gandhi, S. K. 1991. Evaluation of different fungitoxicants against early blight of tomato. *Agricultural Science Digest*. **11:** 201-202.

Mathur, K. and Shekhawat, K.S. 1986. Chemical control of early blight in *Kharif* sown tomato. *Indian J. Mycol. Plant Pathol.* **16:** 235-238.

Mayee, C. D. and Datar, V. V. 1986. Phytopatholometry Technical Bulletin-1. *Marathwad Agril. Univ.*, Parabhani, P.25.

Namanda, S., Olanya, O. M., Adipala, E., Hakiza, J. J. and El-Bedewy, R. 2004. Fungicide application and host resistance for potato late blight management: benefits assessment from on-farm studies in S.W. Uganda. *Crop. Prot*. **23:** 1075-1083.

Nashwa, S. M. A. 2011. Control of early blight disease by certain aqueous plant extracts. *Plant Pathology J.* **10(4):**187-191.

Nikam, P.S., Suryawanshi, A.P. and Chavan, A.A. 2014. *In vitro* efficiency of systemic and non-systemic fungicides against *Alternaria solani*. *J. Mycol. Plant Pathol.* **44(3):** 227-392.

Pandey, K. K., Pandey, P. K. and Satpathy, S. 2002. Integrated management of disease, and insects of tomato, chilli and cole crops. Tech. Bull. **9:** 7.

Patel, R. L. and Choudhary, R.F. 2010. Management of *Alternaria solani* causing early blight of tomato with fungicides. *J. Plant Dis. Sci.* **5(1):** 65-67.

Patil, M. J., Ukey, S. P. and Raut, B. T. 2003. Evaluation of fungicides and botanicals for the management of early blight (*A. solani*) of tomato. *PKV Res. J.* **25(1):** 49-51.

Prasad, Y. and Naik, M.K. 2003. Evaluation of genotypes, fungicides and plant extracts against early blight of tomato caused by *Alternaria solani*. *J. Plant Protec.* **31:** 49-53.

Rotem, J. and Reichert, I. 1964. Dew - a principal moisture factor enabling early blight epidemics in a semiarid region of Israel. *Plant Dis Rep*. **48:** 211-215.

Saha, P. and Das, S. 2015. Temporal and spatial epidemic development of early blight (*Alternaria solani* Ell. and Mart.) in tomato as a function of different fungicides treatment. *J. Mycol. Plant Pathol.* **45(1):** 40-47.

Sahu, D. K., Khare, C. P. and Patel, R. 2013. Seasonal occurrence of tomato disease and survey of early blight in major tomato growing regions of Raipur District.*The Ecoscan*. **4:**153-157.

Sali, V. M., Manjusha, G., Bhoy, B. B. and Satish, R. 2010. Efficacy of different fungicides against early blight of tomato. *J. Plant Dis. Sci.* **5(1):** 86-89.

Schmitz, H. 1930. A suggested toximetric method for food preservation indust. and Engine Chem. Analyst. Ed. **4:** 361-363.

Sharma, R. N. and Gaur, R. B. 2009. Management of post-harvest core rot, *Alternaria alternata* in Kinnow, *Citrus deliciosa* fruits, *Indian J. Plant Prot.* **37(1/2):** 207-210.

Sherf, A. F. and Macnab, A. A. 1986. Vegetable diseases and their control. *J. Wiley and Sons*, New York, pp. 634-640.

Singh, N. K., Saxena, R. P., Pathak, S. P. and Chauhan, S. K. S. 2001. Management of *Alternaria* leaf spot disease of tomato. *Indian Phytopath*. **54:** 508.

Sohi, H. S. 1984. Present status of our knowledge of imperfect fungal diseases of selected vegetables in India and future needs. *Indian J. Mycology and Plant Pathology*. **14:** 1-34.

Tofoli, J. G., Domingues, R. J., Garcia, J. O. and Kurozawa, C. 2003. Tomato early blight control by fungicides and its effects on yield. *Summa Phytopathologica*. **29:** 225-233.

Verma, N. and Verma, S. 2010. *Alternaria* disease of vegetable crops and new approach for its control. *Asian J. Exp. Biol. Sci.* **1(3):** 681-692.

Vincent, J. M. 1947. Distortion of fungal hypae in the presence of certain inhibitors. *Nature*. **159:** 239-241.