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Assessment of fungicides against early blight of tomato induced by *Alternaria solani* (Ellis & Martin) under field conditions

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Abstract
Tomato (*Lycopersicon esculentum* Mill*)* is an important vegetable crop cultivated in almost all the areas of the country. Tomato, early blight caused by *Alternaria solani* has been known to cause severe yield losses. Hence, attempts were made to develop an effective strategy to manage the disease. Present investigations were carried out at Jagannath University Chaksu during the year 2018-19 and 2019-20. Early blight infected leaves of tomato were collected from near by areas of Jaipur, Dausa, and Tonk districts of Rajasthan revealed the association of the *Alternaria* pathogen. In the present studies the efficacy of some newer molecules like Difenconazole, Propiconazole, Hexaconazole Azoxystrobinn, Picoxystrobin, Pyraciostrobin along with commonly used chemical Mancozeb against early blight of tomato were tested using Pusa Ruby as a cultivar. A control plot with no application of fungicide was used as a check. Average yield was calculated after final picking. All the fungicidal application was found significantly superior over control in minimizing the disease. Hexaconazole (@500ml/ha.) was found significantly superior over all other treatments showing disease severity (8.50%) which is closely followed by Propiconazole (@ 500ml/ha.) with PDI (10.47%). Per cent reduction of early blight was noted to the tune of 68.91 and 61.70% respectively. (2018-19). Similar trends were also obtained in (2019-20) with PDI 3.81 and 5.60% in both the treatments. Per cent reduction in disease was recorded 83.91 and 82.12% when the crop was sprayed by Hexaconazole and Propiconazole respeively. All the treatments were significantly enhance the yield over control. The maximum yield (34.01 and 33.56 T/ha) was recorded when the crop was sprayed by Hexaconazole in both the year of testing which was followed Propiconazole having yield of (32.66 and 30.19 T/ha.) in both the years of testing.

Keywords: Alternaria blight, Tomato, *Alternaria solani*, fungicides, disease intensity

Introduction
Tomato is one of the most widely grown vegetable crops in the world. It is second most important solanaceous vegetable crop next to the potato. The area under cultivation tomato is about 4.8 million ha with a production of 163.9 million tonnes. The major tomato producing countries are China, India, USA, Turkey, Egypt, Iran and others. India ranks second after China in both quantity and value wise. Tomato cultivation in India occupied an area of 789.2 thousand ha with the production of 19759.3 million tonnes (Horticulture statistics 2018). In Rajasthan tomato is grown about 18.12 thousand hectares of land with the production of 88.73 million tones (Horticultural statics 2018) Andhra Pradesh leads in the tomato production in India with a production rate of 5.218 million tonnes, followed by Karnataka. There is a gradual increase in the area under tomato while the production has been fluctuating because the crop is affected by various diseases and insect pest damage.

Tomato early blight disease caused by *Alternaria solani* become the most destructive in all over the world and yield losses up to 80% (Chandravanshi *et al.*, 1994) [6]. Balanchard, 1992 [5]; Gomaa, 2001 [12]; Abdel-Sayed, 2006 [3] and Abada *et al*., 2008 [2]. Reported several diseases on tomato caused by fungi, bacteria, viruses, nematodes and abiotic factors. Early blight is the most threatening one among the fungal diseases, caused by *Alternaria solani* (Gomaa, 2001 [12]; Abdel-Sayed, 2006 [3] and Abada *et al*., 2008) [2], which results a drastic reduction in the quantity and quality of fruit yield of tomato. In the tropical and sub-tropical areas early blight of tomato is an important disease. Now a day it can be observed on all continents of the world.

The disease become serious in warm and humid regions (Sherf and MacNab, 1986) [25] and in semiarid areas where prolonged night dew is frequently observed (Rotem and Reichert, 1964) [24] and high relative humidity (Lawrence *et al*., 1996) occurs. The *Alternaria solani* can causes disease in tomato, potato and eggplant. The pathogen 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) [11] and it is disseminated by fungal spores (Datar and Mayee, 1981) [9]. The disease become severe and limiting factor for successful cultivation of tomato and causes yield losses varies from 15-100% (Sohi, 1984 and Mathur and Shekhawat, 1986) [28, 20]. In India Tomato crop is damaged every year due to severe infection of *A. solani*. The disease severity was recorded up to 90% in Varanasi region by Pandey *et al*., 2002 [22]. Primary methods of controlling early blight include avoidance 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) [21, 15, 17]. Cultivation of resistant varieties is the ultimate control of this disease. However heritable resistance has been reported for *A. solani* (Christ, 1991) [8] the disease can primarily managed by use of foliar fungicides.

Many workers had done lot of works based on the chemical control on the management of early blight of tomato. Application of fungicides is the most effective method of *Alternaria* blight control reported by earlier researchers 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) [29]. Ashour (2009) [4] observed that application fungicides showed most efficient in managing the natural infection of the early blight and enhancing the fruit yield compared with antioxidants as well as the alternation between them. Effective management by application of Mancozeb in reducing the disease intensity and increase the yield of Pusa Ruby reported by (Maheswari *et al*., 1991; Gondal *et al*., 2012 and Chourasiya *et al*., 2013) [19, 13, 7]. Patil *et al*. (2003) [23] reported that carbendazim was best fungicides to minimize the disease incidence and highest fruit yield while according to Datar and Mayee (1985) [10], Fentin hydroxide and mancozeb were superior for the controlling the disease. A Application of hexaconazole (0.05%) and azoxytrobin (0.2%) were found effective in managing early blight of tomato Kumar *et al*. (2007) [16].

Most of the new generation fungicides are highly specific and single site in mode of action. Thus a novel fungicide with novel mode of action needs to be identified and evaluated under field conditions. In present study our objective is to evaluate some newer fungicides to manage early blight of tomato.

Materials and Methods

Field trials on the evaluation of fungicides were conducted at the Research Farm, of Jagannath University, Chaksu, Jaipur during *Rabi* 2018-19 and 2019-20.One month old tomato seedlings raised in nursery were transplanted to in a plot size of 3 x 2 m experimental plots. Plant to plant spacing were kept 45 cm and row spacing was maintained of 60 cm the experiment was laid out in randomized block design with three replications. Pusa Ruby variety was used for evaluation of fungicides. All recommended agronomic practices of the zone were adapted. In all seven fungicides were evaluated for their efficacy against early blight of tomato these are Difenconazole, Propiconazole, Hexaconazole Azoxystrobinn, Picoxystrobin, Pyraciostrobin along with commonly used chemical Mancozeb and untreated plot was maintained as control.

Fungicidal application of treatments was done by Knapsack sprayer. Three sprays of fungicides were applied at regular intervals fifteen days, thirty days and 45 days of the initiation of the disease. Data on the disease severity was recorded after every fifteen days intervals of each spray. Sprays of each fungicide were applied after the initiation of the disease. Tomato leaf damage by *A. solani* Five plants were selected randomly in each plot and observations on severity of the disease on the foliage was recorded using 0-5 scale of Horsefall and Barette, 1945 [14] (Table 1) and percent disease index (PDI) was calculated using formula of Wheeler (1969) [30] as given below:

$$PDI = \frac{\text{Sum of all the numerical disease rating X 100}}{\text{Total No. of leaves observed X Maximum disease rating (5)}}$$

In the field experiments well mature and ripen tomato fruits were harvested regularly in all the replicated treatments. The fruit yield per plot was recorded and extrapolated to give the value of fruit yield in tones per hectare.

Statistical analysis

The disease severity data was transformed arcsine values before analysis of variance (ANOVA). Recorded data were subjected to statistical analyzed and presented in table in results.

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

Scale	Description of the symptom
0	Leaves free from infection
1	Small irregular spots covering <5% leaf area
2	Small irregular brown spots with concentric rings covering 5.1-10% leaf area
3	Lesions enlarging, irregular brown with concentric rings covering 10.1-25% leaf area
4	Lesions coalease to form irregular and appears as a typical blight symptom covering 25.1-50% leaf area
5	Lesions coalease to form irregular and appears as a typical blight symptom covering >50% leaf area

Results and Discussion

Observations on severity of early blight of tomato were recorded after fifteen days of each spray. It has been observed that in all treatments per cent disease index increased with age of the plants. Data on disease severity showed that all fungicides tested reduced the disease intensity significantly compared to control. All the fungicidal application was found significantly superior over control in minimizing the disease. Hexaconazole (@500ml/ha.) was found significantly superior over all other treatments showing disease severity (8.50%) which is closely followed by Propiconazole (@ 500ml/ha.) with PDI (10.47%). Per cent reduction of early blight was noted to the tune of 68.91 and 61.70% respectively. (2018-19) (Table: 1). Similar trends were also obtained in (2019-20)

with PDI 3.81 and 5.60% in both the treatments (Table: 2). Per cent reduction in disease was recorded 83.91 and 82.12% when the crop was sprayed by Hexaconazole and Propiconazole respeively.

Other fungicides such as Difenconazole, Azoxystrobinn, Picoxystrobin, Pyraciostrobin and mancozeb also found effective against *A. solani* among the tested fungicides. All the treatments were significantly enhance the yield over control. The maximum yield (34.01 and 33.56 T/ha) was recorded when the crop was sprayed by Hexaconazole in both the year of testing which was followed by Propiconazole having yield of (32.66 and 30.19 T/ha.) in both the years of testing.

Sudarshana *et al*. (2012) and Vikash *et al*. (2018) reported hexaconazole showed significant decrease in disease intensity and increase in yield in there studies. Raavi Sreenivasulu *et al*. (2019) [26] and Sharma *et al*. (2018) [27] also reported application of Propiconazole shown reduction in disease and increase in yield of tomato. Similar results were observed in our present studies.

In conclusion, all the evaluated fungicides showed significant effect against Alternaria leaf blight of tomato under *field conditions.* But Hexaconazole followed by Propiconazole among tested fungicides were shown highly suppression of *Alternaria solani* in field conditions.

Table 2: Evaluation of different fungicides against early blight of tomato (2018-19)

Treatment No.	Treatment name	Doses Per Hectare	PDI 15 th day of each spray			Yield Tons/ha	Per cent reduction over control
			1st Spray	2nd Spray	3rd Spray		
T1	Difenconazole 25% EC	250 ml	7.36	11.32	13.09	29.11	52.12
T2	Propiconazole 25% EC	500 ml	5.87	8.11	10.47	32.66	61.70
T3	Hexaconazole 5% EC	500 ml	5.42	7.43	8.50	34.01	68.91
T4	Azoxystrobin 23% SC	500 ml	7.01	11.38	13.18	32.04	51.79
T5	Picoxystrobin 22.52% SC	400 ml	7.01	10.16	12.48	32.58	52.12
T6	Pyraclostrobin 20% WG	500 g	10.18	14.12	16.90	28.42	27.21
T7	Mancozeb 75% WP	1500 g	10.88	18.65	19.38	25.92	29.11
T8	Control	-	12.72	21.26	27.34	19.33	-
	CD		1.98	1.40	1.18	1.44	
	SEM		0.67	0.47	0.53	0.48	
	CV		6.19	4.07	4.16	5.88	

Table 3: Evaluation of different fungicides against early blight of tomato (2019-20)

Treatment No.	Treatment name	Doses Per Hectare	PDI 15 th day of each spray			Yield Tones/ha	Per cent reduction over control
			1st Spray	2nd Spray	3rd Spray		
T1	Difenconazole 25% EC	250 ml	5.41	6.41	10.36	27.93	66.93
T2	Propiconazole 25% EC	500 ml	2.26	2.51	5.60	30.19	82.12
T3	Hexaconazole 5% EC	500 ml	3.47	4.12	3.81	33.56	83.91
T4	Azoxystrobin 23% SC	500 ml	5.39	6.34	8.91	29.54	71.56
T5	Picoxystrobin 22.52% SC	400 ml	4.03	5.05	8.76	28.59	72.04
T6	Pyraclostrobin 20% WG	500 g	6.32	7.24	12.54	31.42	59.97
T7	Mancozeb 75% WP	1500 g	7.48	8.19	18.40	24.75	25.31
T8	Control	-	10.84	18.64	31.33	21.13	-
CD			2.37	1.28	1.67	3.63	
SEM			0.75	0.43	0.57	0.93	
CV			10.03	5.42	5.10	5.69	

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