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Efficacy of fungicides against early blight (*Alternaria solani* Ellis and Martin) jones and grout of tomato under field conditions of Kashmir

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Abstract
Field studies were conducted to evaluate the comparative efficacy of six systemic and four non-systemic fungicides against early blight of tomato caused by *Alternaria solani* (Ellis and Martin). The experiments conducted during Kharif 2014 to study effect of some promising fungicides found under *in vitro* studies as foliar sprays against early blight of tomato. Three foliar sprays of at 15 days interval with Difenoconazole 25 EC was the most effective fungi toxicant reducing the disease incidence to 23.48 per cent from 61.23 per cent, unsprayed check. The other fungicides in order of their decreasing efficacies were Flusilazole 40 EC >Hexaconazole 5 EC >Mancozeb 75 WP. Propineb 70 WP proved least efficacious among the test fungitoxicants reducing the disease incidence to 43.70 per cent from 61.23 per cent, unsprayed check. Similarly Difenoconazole 25 EC again proved most effective fungitoxicant in case of disease intensity reducing the disease intensity to 16.39 as against 41.31 per cent observed in unsprayed check. The other fungicides in order of their decreasing efficacies were Mancozeb 75 WP >Flusilazole 40 EC >Hexaconazole 5 EC. Propineb 70 WP proved least efficacious among test fungi toxicants reducing the disease intensity to 24.11 per cent. Difenoconazole 25 EC gave the highest disease control of 61.67 and 60.32 per cent in case of disease incidence and disease intensity respectively while the least per cent disease control of 43.70 and 41.63 per cent respectively was given by Propineb 70 WP.

Keywords: *Alternaria solani*, fungitoxicants, disease incidence, disease intensity

Introduction
Tomato (*Solanum lycopersicum* L.) is second most important remunerable solanaceous vegetable crop after potato. It is grown for its edible fruits, which can be consumed fresh or in processed form (Jones 2008) [10]. (Caicedo and Peralta, 2013) [6]. From the nutritional point of view, Tomato is considered as highly nutritious because of its high contents of vitamin A and C as well as lycopene-natural antioxidant, which is not found in the other solanaceous crops. (Anonymous, 2008) [4]. In India, major tomato growing states are Maharashtra, Bihar, Uttar Pradesh, Karnataka and west Bengal. The total area under crop in India is about 1204 thousand hectares with annual production of about 19402 metric tonnes which accounts for 11.5% of the total vegetable production (FAO, 2015) [8]. Globally tomato is cultivated in 140 countries of the world with an annual production of 16.82 metric million tonnes (Anonymous, 2012) [5]. The production of tomato in Jammu and Kashmir during the year 2014 was 0.008 metric million tonnes which accounts for 28.50 per cent of the total vegetable production of the State (FAO, 2014) [7]. Introduction of some high yielding cultivars of tomato have replaced most of the conventional cultivars monoculturing and because of favourable climatic conditions several fungal diseases have been reported to the attacking the crop.

Tofoli *et al.* (2003) [9] evaluated the effectiveness of various groups of fungicides for controlling early blight and recorded their effect on tomato fruit yield, and found difenoconazole as effective fungicide which reduce the disease severity and simultaneously increase the yield. Sawant and Desai (2001) [8] studied the efficacy of dodine 65 WP and mancozeb 75 WP with alachlor 50 EC and acephate 75 SP against early blight and reported that application of alachlor before transplanting + 2 applications of dodine + 2 applications of acephate was most effective in management of the disease.

Insect pests are the major biotic constraints to vegetable production in India given that they not only inflict direct damage to host crops, but also many of them act as vectors for several viral diseases. Some of the major pests which attack tomato crop are Tomato fruit worm *(Helicoverpa armigera),* whitefly (*Bemisia tabaci*) and serpentine leaf miner (*Liriomyza trifolii),* Flea Beetle, Aphids, Tomato Hornworm, Yellow striped Armyworm. Among all these pests Tomato fruit worm, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) is a polyphagous pest and major threat to tomato crop causing significant yield loss [16]. Worldwide annual crop losses due to *H. armigera* alone are approximately 5 billion US dollars [14]. The most destructive pest infesting these crops is a highland whitefly, *Trialeurodes vaporariorum* Westwood (Homoptera: Aleyrodidae) [15] that sucks the sap of plant leaves, stems, buds and flowers. *Bemisia tabaci* Gennadius (Homoptera: Aleyrodidae) has developed resistance to numerous conventional insecticides throughout the world [9] leaving fewer effective insecticides to control the pest in the market [12]. Meanwhile several species of natural enemies have been reported to reduce the population of whiteflies in the fields [2]. Several workers have studied the in vitro management aspect of the disease and recommended some effective fungicides against the pathogen. But no systematic work on this aspect has been undertaken in Jammu & Kashmir. Keeping in view the foregoing facts, the present study was undertaken

Methods and Materials

The present investigations were conducted in the Division of Plant Pathology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-K), Shalimar, Srinagar. Six systemic and four non-systemic fungitoxic cants were evaluated under field conditions for their efficacy against the early blight of tomato. The treatments that proved most effective under *in vitro* studies were evaluated as foliar spray under field conditions for their efficacy in controlling the disease. The crop was maintained by following agronomical practices except plant protection measures. Three sprays of each fungi toxicants (at their recommended concentrations) were given at an interval of 15 days starting from the appearance of initial symptoms. Three replications for each treatment were maintained in randomized block design. Treatment where only water was sprayed served as check. Observation on disease incidence and intensity were recorded 15 days after the last spray. Each test fungi toxicant was evaluated at different concentrations including check as under:

Table 1: Chemica name

S. No.	Common name	Nomenclature chemical name
1.	Myclobutanil 10WP	2-(4-chlorophenyl)-2-(1,2,4-triazol-1-ylmethyl) hexanenitrile
2.	Thiophenate methyl 70WP	Dimethyl4,4–(o-phenylene) bis (3-thioallophanate)
3.	Flusilazole 40EC	1-((bis(4-flourophenyl) methylsilyl)methyl)-1-H-1 triazole
4.	Difenoconazole 25EC	Cis, trans-3-chloro-4-[4-methyl-2(1-H-1,2,4-triazol-1-ylmethyl)-1,3-dioxolan-2-yl]phenyl 4-chlorophenyl ether
5.	Pyraclostrobin 20WG	Methyl-*N*-[2-[[[1-(4-chlorophenyl) pyrazol-3-yloxymethyl]]-*N*-methoxycarbanilite
6.	Hexaconazole 5EC	2-(2,4-dichlorophenyl)-1-(1 h-1,2,4 triyl) hexan-2-ol
7.	Dodine 65WP	*N*-dodecyl guanadineoxitate
8.	Mancozeb 75WP	Manganese ethylene bis-di thiocarbamate plus zinc
9.	Polyram 70 WG	(1-methyl-1,2-ehanediyl) bis-carbamodithioc acid
10.	Propineb 70 WP	Zinc ethylene bis di thiocarbamate

Results and Discussion

In vivo management of the disease

The experiments were conducted during Kharif 2014 to study effect of some promising fungicides found under *in vitro* studies as foliar sprays against early blight of tomato. The results on disease incidence & disease intensity are presented in Table 2&3.

Disease incidence on leaves

Perusal of the data obtained (Table 2) during kharif 2014 revealed that Difenoconazole 25 EC was the most effective fungi toxicant reducing the disease incidence to 23.48 per cent from 61.23 per cent, unsprayed check. The other fungicides in order of their decreasing efficacies were Flusilazole 40 EC >Hexaconazole 5 EC >Mancozeb 75 WP >Propineb 70 WP proved least efficacious among the test fungitoxicants reducing the disease incidence to 43.70 per cent from 61.23 per cent, unsprayed check.

Disease intensity on leaves

Similarly, the data obtained (table 3) during kharif 2014 revealed that Difenoconazole 25 EC was proved most effective fungitoxicant reducing the disease intensity to 16.39 as against 41.31 per cent observed in unsprayed check. The other fungicides in order of their decreasing efficacies were Mancozeb 75 WP >Flusilazole 40 EC >Hexaconazole 5 EC. Propineb 70 WP proved least efficacious among test fungi toxicants reducing the disease intensity to 24.11 per cent.

Table 2: Effect of various fungitoxic cants on incidence of early blight (*Alternaria solani)* of tomato (*Solanum lycopersicum*) c.v Marglobe under field conditions during kharif 2014

Fungitoxicant	Concentration (%)	Disease incidence (%)	Per cent disease control
Difenoconazole 25 EC	0.03	23.48 (28.97)	61.67
Flusilazole 40 EC	0.02	24.30 (29.52)	60.31
Hexaconazole 5 EC	0.03	25.74 (30.47)	57.75
Mancozeb 75 WP	0.3	27.96 (31.91)	54.37
Propineb 70 WP	0.3	34.80 (36.13)	43.70
Control (water spray)		61.23 (51.47)	

C.D ($P \leq 0.05$)
Mean disease incidence = 0.91
Figures in parenthesis are arc sine transformed values.

Table 3: Effect of various systemic and non-systemic fungitoxic cants on intensity of early blight (*Alternaria solani)* of tomato (*Solanum lycopersicum*) c. v Marglobe under field conditions

Fungitoxicant	Concentration (%)	Mean disease intensity	Per cent disease control
Difenoconazole 25 EC	0.03	16.39 (23.86)	60.32
Flusilazole 40 EC	0.02	21.00 (27.26)	49.16
Hexaconazole 5 EC	0.03	22.28 (28.15)	46.06
Mancozeb 75 WP	0.3	20.36 (26.81)	50.71
Propineb 70 WP	0.3	24.11 (29.39)	41.63
Control (water spray)	-	41.31	-

C.D ($P \leq 0.05$)
Mean disease intensity = 1.20
Figures in parenthesis are arc sine transformed values.

The systemic and non systemic fungitoxic cants tested *in vitro* were also evaluated in field during 2014 to record their field efficacy against early blight of tomato. Difenoconazole 25 EC was most efficacious among fungi toxicants evaluated reducing disease incidence and intensity to 23.48 and 16.39 per cent from 61.23 and 41.31 per cent in unsprayed check. The next in order of their decreasing efficacy were Mancozeb 75 WP >Propineb>Flusilazole 40 EC >Hexaconazole 5EC. Excellent disease control with Difenoconazole 25 EC has been reported by Andrew *et al.* (2010) [3] and Tofoli *et al.* (2003) [17]. The results were similar that given by Kumar *et al.* (2007) [11] who also reported that hexaconazole (0.05%) and azoxytrobin (0.2%) was very effective in managing early blight of tomato. Abhinandhan *et al.* (2004) [1] also reported that in controlling the early blight Dithane M-45, followed by Kavach were very effective in controlling the disease.

Conclusion

The evaluation of fungicides under field conditions against early blight of tomato. Among the systemic fungitoxic cants, difenoconazole 25 EC was the most effective fungitoxic cant reducing the disease incidence and intensity to 23.48 and 16.39 per cent from 61.23 and 41.31 per cent, respectively, from unsprayed check. While Propineb 70 WP proved least efficacious among the test fungitoxic cants reducing the disease incidence and intensity to 34.80 and 21.00 per cent from 61.23 and 41.31 per cent, respectively, from unsprayed check. Hopefully present study will be beneficial for management control agencies.

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