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Evaluation of different fungicides against *Alternaria solani* (Ellis & Martin) Sorauer cause of early blight of tomato under laboratory conditions

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Abstract
Early blight is one of the most damaging disease in tomato production areas worldwide incited by *Alternaria solani*. It reduces the quality and market value of tomato. This disease becomes serious when the season begins with abundant moisture or frequent rainfall by warm and dry weather which are unfavourable for the host and help rapid disease development. In the present study, fungi toxic activity of fungicides, namely Pyroclostrobin 25% EC, Hexaconazole 5% EC, Carbendazim 50% WP, Mancozeb 75% WP and Ridomil MZ 68% WG was evaluated by poisoned food technique at Laboratory of Plant Pathology, in the Division of Plant Pathology, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology-Jammu, Chatha during the year 2017-2018. For the management of early blight of tomato caused by *Alternaria solani*. The results showed that all the tested fungicides at different concentrations significantly ($P \leq 0.0001$) inhibit the mycelial growth of the pathogen compared to control**.** Data regarding mycelial growth presented in the table 1 revealed that at 500 ppm, Pyroclostrobin was found most effective there by inhibiting the maximum mycelial growth (97.7%) of *A. solani* followed by Hexaconazole (91.1%) and carbendazim (90%). Ridomil was found least effective as inhibiting the mycelial growth only up to 42.2%.

Keywords: *Alternaria solani*, fungicides, inhibition percentage, poisoned food technique

Introduction
More than 800 million people in developing countries have insufficient food supply and at least 10-15% of agriculture products are lost due to plant diseases (Strange and Scott, 2005). Plant diseases are caused by abiotic and biotic factors, genetic disorders and living infectious agents including various pathogens such as fungi, bacteria, viruses, viroids, phytoplasms, nematodes, parasitic plants and protozoan's (Agrios, 2005) [1]. Tomato (*Lycopersicon esculentum* Mill) is one of the most important vegetable crops in the world and belongs to *Solanaceae* family. The disease of early blight was first recorded in 1882 in New Jersey, USA (Bose and Som, 1986) [3]. Alternaria leaf blight of tomato caused by *Alternaria solani* (Ellis and Martin) Jones and Grout, is a soil inhabiting air-borne pathogen responsible for leaf blight, collar and fruit rot of tomato disseminated by fungal spores (Datar and Mayee, 1981) [4]. It is an important disease of tropical and sub-tropical areas. Distinctive bulls-eye pattern of leaf spots with concentric rings of spores surrounded by a halo of chlorotic leaf area are common. Leaves turn yellow and dry up when only a few spots are present (Gleason and Edmonds, 2006) [7]. The early blight was the most catastrophic diseases incurring loss both at pre and post-harvest stages causing 35 to 78 per cent reduction in yield (Jones *et al*., 1993) [8]. The effective management of the disease could be through cultural practices, chemical, biological control and use of resistant variety (Ankur *et al*., 2018). This disease is controlled mainly by the application of agrochemicals. Regarding the management of early blight of tomato many workers had done lot of works based on the chemical control. Mancozeb was also effective in reducing the disease intensity and increase the yield of Pusa Ruby (Kumar *et al*., 2013, Maheswari *et al*., 1991. and Gondal *et al*., 2012) [10, 21,]. Patil *et al*. (2003) [14] reported that carbendazim was best fungicides to minimize the disease incidence and highest tuber yield while according to Datar and Mayee (1986) [5], Fentin hydroxide and mancozeb were superior for the controlling the disease. Kumar *et al*. (2007) [11] reported that hexaconazole (0.05%) and azoxytrobin (0.2%) was very effective in managing early blight of tomato. However, the worldwide trend towards environmentally safe methods of plant disease control in sustainable

agriculture calls for reducing the use of these synthetic chemical fungicides (Koley *et al*., 2015) [9]. The wide and indiscriminate use of chemical fungicides has been the cause of development of resistance among plant pathogens, leading to the occurrence of serious diseases. Due to this, there is an increasing interest to obtain alternative antimicrobial agents (bio control agents) and plant extracts for using in plant disease control systems. Plant products of recognized antimicrobial spectrum could appear in food conservation systems as main antimicrobial compounds or as adjuvant to improve the action of other antimicrobial compounds (Datar and Mayee, 1981) [4]. Present study was aimed to determine the efficacies of different doses of fungicides, botanicals and *Bacillus sunbtillis*.

Materials and Methods

The present study was conducted in Laboratory of Plant Pathology, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology-Jammu, Chatha during the year 2018-19. The details of materials used and the methodology adopted in the present investigation are briefly described below:

In vitro efficacy of Fungicides

In vitro efficacy of Plant Extracts

The poisoned food technique (Falck, 1907) was followed to evaluate the efficacy of five fungicides (Pyroclostrobin 25% EC, Hexaconazole 5% EC, Carbendazim 50% WP, Mancozeb 75% WP and Ridomil MZ 68% WG) against *A. solani* at different concentrations. Fungicides were added to the potato dextrose agar medium before sterilization as per treatment detail. Five mm disc of *A. solani* culture was taken from seven days old culture and placed at center of petri dish. The activity of fungicides were recorded by measuring the colony diameter of *A. solani* in each treatment and compared with control.

Observations to be recorded

The radial growth of the fungus on the poisoned medium was recorded at time of mycelium growth reached 90 mm in control. Per cent inhibition of mycelium growth of the fungus was calculated by using the formula described by Vincent (1927).

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

Where,
I= Per cent mycelial growth inhibition
C= Colony diameter in control (mm)
T= Colony diameter in respective treatment (mm).

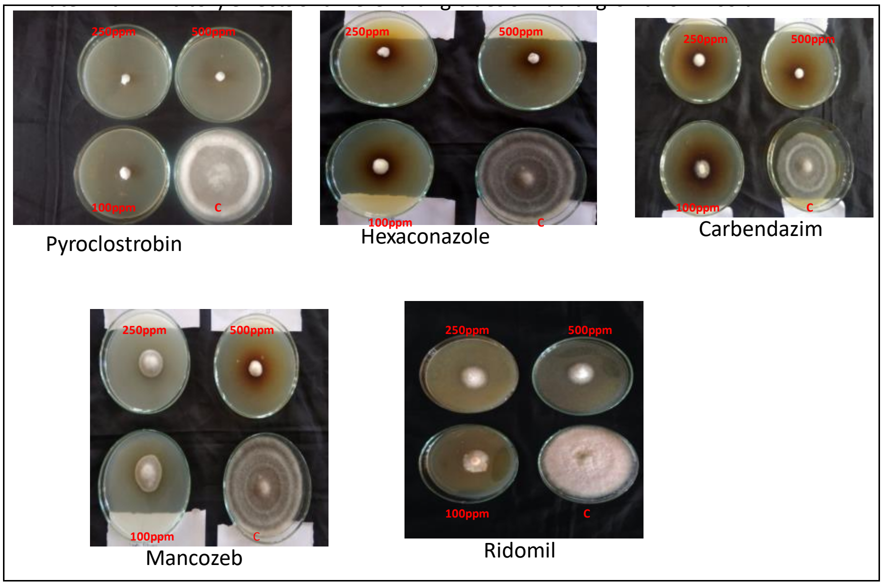
Results and Discussions

Five different fungicides viz., Pyroclostrobin (EC 25), Hexaconazole (EC: 5), Carbendazim (50% WP), Mancozeb (75% WP) and Ridomil Gold MZ 68 WG were evaluated under *in vitro* conditions at three different concentrations (100ppm, 250ppm and 500ppm) for knowing their efficacy against, *A. solani* causing early blight of tomato using poisoned food technique (PFT). The results showed that all the tested fungicides at different concentrations significantly ($P \leq 0.0001$) inhibit the mycelial growth of the pathogen compared to control. Data regarding mycelial growth presented in the table 1 revealed that at 500 ppm, Pyroclostrobin (Plate 1) was found most effective there by inhibiting the maximum mycelial growth (97.7%) of *A. solani* followed by Hexaconazole (91.1%) and carbendazim (90%). Ridomil was found least effective as inhibiting the mycelial growth only up to 42.2%. Fungicide application is one of the keen tool against disease control in plants if use in integrated manner. Therefore, the fungicides should not only be able to inhibit the disease but also leads to increased yield of the crop, should be environmentally safe and should be useful for the local growers in controlling the disease.

Table 1: Evaluation of different fungicides against *Alternaria solani* under laboratory conditions

Fungicide	Concentration (ppm)	Radial growth (mm)	Inhibition (%)
Pyroclostrobin (EC:25)	100	03.0	93.3 (63.49)
	250	02.0	95.5 (66.80)
	500	01.0	97.7 (72.73)
Hexaconazole (EC:5)	100	09.0	80.0 (70.52)
	250	07.0	84.4 (75.10)
	500	04.0	91.1 (81.47)
Carbendazim (50% WP)	100	15.0	66.6 (39.28)
	250	11.0	75.5 (43.10)
	500	04.0	91.0 (45.67)
Mancozeb (75% WP)	100	27.0	40.0 (54.74)
	250	24.0	46.6 (60.38)
	500	23.0	51.1 (72.73)
Ridomil MZ 68% WG	100	31.0	31.1 (33.95)
	250	30.0	33.3 (35.30)
	500	19.0	42.2 (40.56)
Control		45.0	0 (89.17)

CD 0.175, SE±(m) 0.060 Figures in parentheses are transformed angular values



Plant 1: Inhibitory effects of different fungicideson radial growth of *A. solani*

The above results are in conformity with the findings of Arunakumar (2006) [2] who evaluated the bio efficacy of chlorothalonil (@ 0.1, 0.2 and 0.3per cent), pyroclostrobin (@ 0.05, 0.1, and 0.15 per cent), axoxystrobin (@ 0.05, 0.1, and 0.15 per cent) and mancozeb (@ 0.1, 0.2 and 0.3%) against *Alternaria solani* causing early blight of tomato. It was observed that azoxystrobin proved most effective in inhibiting the mycelial growth (78.60per cent) of the fungus followed by pyroclostrobin with an inhibition percentage of 78.02 per cent. Similar results were reported by Singh and Singh (2006) [15] evaluated bio efficacy of seven different fungicides viz., azoxystrobin, chlorothalonil, propineb, mancozeb, copper oxychloride and copper hydroxide at 250, 500, 1000, 2000 and 2500 ppm and Hexaconazole at 50, 100, 200, 500 and 1000ppm against *Alternaria alternata* causing early blight of tomato. Every fungicide was found effective in inhibiting the mycelial growth of the fungus but Hexaconazole was found most effective with 100 per cent inhibition rate. Mesta *et al.*, (2009) [13] also tested five different fungicides viz., chlorothalonil and captan (0.1, 0.2 and 0.3 per cent conc.), difenoconazole and Hexaconazole (0.05, 0.1, and 0.15 per cent conc.) against *Alternaria helianthi* and it was found that maximum inhibition of fungal growth (72.87 per cent) mycelial growth was observed in Hexaconazole. Difenoconazole was also found effective in inhibiting the mycelial growth (72.61 per cent) followed by captan (50.43 per cent).

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