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EFFICACY OF PLASTIC MULCHING, MARIGOLD INTERCROPPING AND FUNGICIDAL SPRAY AGAINST EARLY BLIGHT OF TOMATO CAUSED BY *ALTERNARIA SOLANI*

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ABSTRACT
Early blight of tomato caused and disseminate by conidial spores of *Alternaria solani*. Conidial spores of *A. solani* are seed, soil and air borne therefore any single method of disease management will not control the disease thus in this study a consortia of plastic mulching, marigold intercropping and spray with fungicides like propineb, aureofungin and azoxystrobin have been evaluated to reduce disease severity.Treatments having plastic mulching and marigold intercropping found to hinders the conidial movement than the non mulched and non intercropped. Treatment with consortia of plastic mulching, marigold intercropping and 3 sprays with azxoystrobin 23% SC hinders conidial movement to the maximum extent and reduced disease severity by 52-55% and only 2.0-2.1% fruit losses were recorded which ultimately fetch maximum fruit yield of 31.5- 33.4 t/ha yield respectively in both the experimental years. At the end of the evaluation period (9 WAT), the reductions in conidial density due to consortium treatment of plastic mulching, marigold intercropping and spray of azoxystrobin 23% SC were 25.8-26.2% and 24.7-25.7% for the consortium treatment of plastic mulching, marigold intercropping and spray of Propineb 70WP, in both the years.

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) occupies a significant position in vegetable production. 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). Among the fungal diseases, early blight also known as target spot disease incited by *Alternaria solani* (Ellis and Martin) Jones and Grout is one of the world's most catastrophic disease of tomato (Abada *et al.,* 2008). The causal organism is air borne and soil inhabiting and is responsible for early blight, collar rot and fruit rot of tomato (Datar and Mayee, 1981). The disease appears on leaves, stems, petiole, twig and fruits under favourable conditions resulting in defoliation, drying off of twigs and premature fruit drop and thus causing loss from 50 to 86 percent in fruit yield (Mathur and Shekhawat, 1986).

Spores of the fungi are one of most important means of dissemination and also used in the identification and classification of the organism. It was well established that the tomato early blight fungus could survive on the infected seeds for several days. Microclimate of the crop canopy also contributes in increasing disease severity. It is observed that disease severity increases with increase in leaf wetness duration at all temperatures. The maximum observed mean disease severity occurred after 24h duration of wetness at 18ºC (Evans *et al.,* 1992). Thus, for the management of the disease a single management practice will not be suffice. An integrated approach can only manage the disease. Intercropping system can alleviate plant disease by promoting soil microbial diversity. Tomato blight disease, for example, could be controlled in the tomato–marigold intercropping system (Go´ mez-Rodrý´guez *et al.,* 2003). Apart from this allelopathic effect of marigold may play significant role. Gu and Mozzola (2003) reported that plant species or genotypes managed potential benefit to soil-borne diseases through root exudates. Earlier workers reported application of fungicides is the most effective method of Alternaria blight control and found that Tetra methyl thiuram disulphide (TMTD), Dithane M-45, Bavistin, Dithane Z-78, Difoltan, Blitox, Captafol and Bordeaux mixture effectively manage the disease (Verma and Verma, 2010). New chemicals like Azoxystrobin and Propineb recently released in India were also found effective in controlling the Alternaria leaf spot of Chinese cabbage which was reported in Poland by Robak (1992).

Therefore in this study a consortia management practices such as plastic mulching, intercropping with marigold and application of new chemical fungicides have been applied to evaluate the effect on reducing disease incidence. We evaluated the effect of tomato – marigold intercropping –

plastic mulching along with fungicidal spray on conidial density as a measure of disease progress in the system and leaf damage by *Alternaria solani*.

MATERIALS AND METHODS

An experiment was performed under field condotions in 2011 and 2012 season at Agriculture Research station of MPUAT, Udaipur located at Banswara, Rajasthan, India. Transplanting of tomato seedlings cv. Abhinav was done in December month in both the year. Eight experimental treatments were framed: T1-Plastic mulching + marigold as intercrop + 3 sprays of propineb 70% @ 2.5g/lit water; T2-plastic mulching + marigold as intercrop + 3 sprays of Aureofungin @ 1.5 g/15 lit water; T3-plastic mulching + marigold as intercrop + 3 sprays of Azoxystrobin 23% SC; T4-Three sprays of propineb, T5-Three sprays of aureofungin; T6-Three sprays of azoxystrobin ; T7-plastic mulching + marigold as intercrop (without any spray); T8-Untreated control.When intercropped, one tomato plant was planted between two marigold plants and spacing between tomato plants was 60 cm and row to row distance was 90 cm while when non-intercropped tomato rows were 90cm apart and plant to plant distance was 30 cm. The 30-day-old marigold seedlings were transplanted during the second week of November, 30 days prior to transplanting tomato. The plot size of each treatment was 4.5 x 3.0m^2 with three replications and the treatments were randomly assigned to each plot. The NPK and FYM were incorporated to the soil as per the recommended dose. Yield of fruit tomatoes were pooled from all the harvests of each plot and expressed as t/ha.

Tomato leaf damage by *A. solani*

Incidence of disease was recorded by selecting 5 plants from each plot. Five leaves were selected from each plant and the area covered by disease was measured on 0-5 scale (Mayee and Datar 1986) and expressed as Percent Disease Index.

Conidial density of *A. solani* in field conditions

Three adhesive traps (microscope slides covered with adhesive) were placed in the centre of each plot, at the tomato canopy level, starting from the second week of January (3 WAT). The traps were changed every 48 h and the number of trapped *A. solani* conidia were counted and recorded under compound microscope.

Statistical analysis

The disease severity data was arcsine transformed before analysis of variance (ANOVA). The package used for analysis was Web Agri Stat Package 2.0 (WASP 2.0) developed by ICAR Research Complex for Goa, India.

RESULTS

Data presented in Table 1 showed that all the treatments significantly reduced early blight disease caused by *A. solani* in both the experimental year. Among all the treatments Plastic mulching + marigold intercropping along with spray of Azoxystrobin 23% SC results in minimum disease intensity of 25.5-28.4% and thereby reduced disease by 52.3-55.6% as compare with control. This treatment was closely followed by plastic mulching + marigold as intercrop and 3 sprays of Propineb 70% WP showed 29.4- 30.2% disease severity which results in 48.9-49.3% reduction in disease severity respectively in both the years. Spray of azoxystrobin 23% SC devoid of plastic mulching and marigold intercropping also showed promising results by reducing disease severity by 38.9- 39.6% as compare with control. When the treatments were considered for fruit loss, only 2.0-2.1% fruit losses were recorded with the application of consortia treatment of plastic mulching, marigold intercropping and 3 sprays with azoxystrobin 23%SC which ultimately fetch maximum fruit yield of 31.5- 33.4 t/ha yield respectively in both the experimental years.

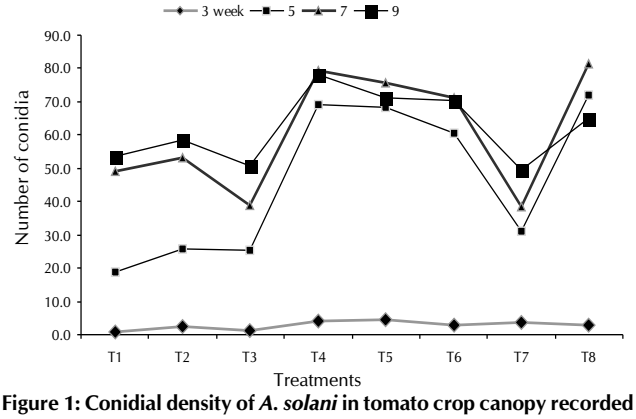

Figure 1: Conidial density of *A. solani* in tomato crop canopy recorded under different treatments for 4 weeks during 2011 growing season

Table 1: Efficacy of consortia treatment of plastic mulching, marigold intercropping and fungicidal spray against early blight of tomato and yield of tomato fruits

Treatment	2011 (PDI %)	2012 % Reduction in PDI	% fruit infection at 12WAT	Yield (t/ha)	PDI (%)	% Reduction in PDI	% fruit infection at 12WAT	Yield (t/ha)
T1	29.4*(32.5)^{e}	48.9	2.6 (9.1)^{e}	28.5 (32.2)^{ab}	30.2 (32.8)^{e}	49.3	3.0 (9.9)^{d}	27.8 (31.8)^{bc}
T2	35.0 (36.1)^{d}	39.1	4.1 (11.7)^{cd}	26.8 (31.1)^{bc}	37.1 (37.1)^{d}	37.7	4.3(12.0)^{bc}	28.6(32.3)^{bc}
T3	25.5 (29.9)^{e}	55.6	2.1 (8.3)^{e}	31.5 (34.1)^{a}	28.4 (31.7)^{e}	52.3	2.0 (8.2)^{e}	33.4 (35.3)^{a}
T4	38.0 (38.0)^{cd}	33.9	4.4 (12.2)^{bcd}	27.1(31.4)^{bc}	44.0(41.4)^{c}	26.2	4.4 (12.1)^{bc}	28.7 (32.4)^{bc}
T5	41.7 (40.2)^{c}	27.5	4.8 (12.7)^{bc}	25.3 (30.2)^{bc}	49.3 (44.6)^{b}	17.3	4.6 (12.4)^{b}	27.3 (31.5)^{bc}
T6	34.7 (35.9)^{d}	39.65	3.9 (11.4)^{d}	28.0 (31.9)^{ab}	36.4 (36.9)^{d}	38.9	3.7 (11.1)^{cd}	30.0 (33.2)^{ab}
T7	48.3 (44.0)^{b}	16.0	5.3 (13.4)^{b}	23.7 (29.1)^{c}	52.9 (46.7)^{b}	11.2	5.2 (13.2)^{b}	26.1 (30.7)^{c}
T8	57.5 (49.4)^{a}	-	7.6 (16.0)^{a}	19.4 (26.1)^{d}	59.6 (50.7)^{a}	-	7.3 (15.6)^{a}	21.5 (27.6)^{d}
CV	4.27		6.3	4.6	3.52		6.1	4.4
CD (p = 0.05)	2.9		1.3	2.5	2.5		1.3	2.5

*Figures in parethesis are arsine trnsformed values; Values in th column superscripted by different letters are significantly (p = 0.05) different from each other

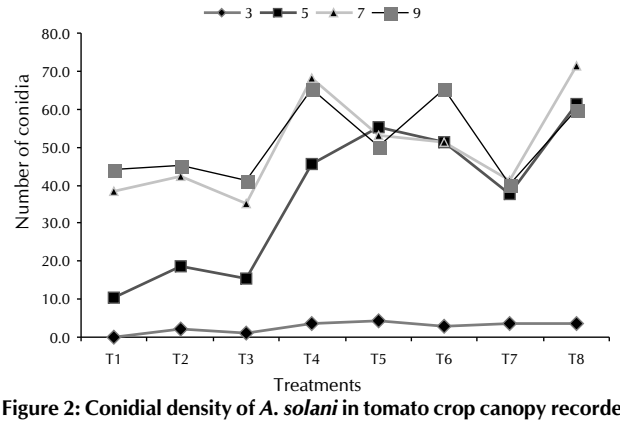

Figure 2: Conidial density of *A. solani* in tomato crop canopy recorded under different treatments for 4 weeks during 2012 growing season

Conidial density of *A. solani* in field conditions

In all the treatments the conidial density of *A. solani* in the air near the tomato canopies increased with time after tomato transplanting during both the growing seasons, 2011and 2012 (Fig. 1 and 2). However, in both seasons the rate of increase in conidial density was significantly ($p = 0.05$) diminished by intercropping with marigold, particularly by consortium of plastic mulching, marigold intercropping and spray of azoxystrobin 23%SC, compared to the control. At the end of the evaluation period (9 WAT), the reductions in conidial density due to consortium treatment of plastic mulching, marigold intercropping and spray of azoxystrobin 23% SC were 25.8-26.2% and 24.7-25.7% for the consortium treatment of plastic mulching, marigold intercropping and spray of Propineb 70WP, in 2011and 2012.

DISCUSSION

The causal organism of early blight of tomato, *A. solani* , which causes great reduction in the quantity and quality of fruit yield overwintered as conidia chlamydospores and mycelium on plant debris and in the soil for as long as 18 months. The dissemination of disease causing conidial spores takes place through seed, soil or air. Hence a consortium of plastic mulching, marigold intercropping and spray of fungicide have been evaluated against this disease. Plastic mulching keeps away the foliage and fruits from soil contact and also cuts down from soil splash on lower canopy as soil often consist disease causing conidial spores. Gomez-Rodriguez *et al*. (2003) found that intercropping of tomato with marigold (*Tagetes erecta* L.) induced a significant reduction in early blight caused by *A. solani*. This was achieved by means of three different mechanisms- (i) the allelopathic effect of marigold on *A. solani* conidial germination, (ii) by altering the microclimatic conditions around the canopy, particularly by reducing the number of hours/day with relative humidity e" 92%, thus diminishing conidial development and (iii) by providing a physical barrier against spreading the conidia. There are several fungicides have been evaluated and found effective in managing early blight of tomato but could not give long term solution. Thus in this integrated approach we have evaluated three fungicides with different nature of mode of action. Propineb70%, a contact fungicide, which interferes on several points of respiration chain, in the metabolism of carbohydrates and proteins, in the cell membrane. Aureofungin,is a heptanes type of antifungal antibiotic. Azoxystrobin, a strobilurin group of broad spectrum fungicide, is excellent inhibitors of spore germination and known for their protectant activity. Our study clearly indicates that plastic mulching, marigold intercropping and 3 sprays with azoxystrobin when applied together gives maximum protection against conidial spores of *A.solani*. The mulching with black plastic also reduced the number of damaged fruits improved their quality and give higher yield. Black plastic mulch was supposed to function as a mechanical barrier preventing a direct contact of the plant with the inoculum of the fungus in the soil and thus give higher marketable yield (Znidarcic *et al*., 2003). Our results clearly depicts effect of intercropping with marigold as against non intercropping. Marigold intercropped plots showed less conidial population as against non intercropped plots. Gomez-Rodriguez *et al*. (2003) also recorded lower conidial density around canopy of tomato- marigold association than in tomato as single crop. According to Morallo (1987), this allelopathic effect is due to the ability of marigold leaves to produce and liberate volatile tiophenes. Treatments with Marigold intercropping with tomato also diminished leaf damage by early blight while non intercropped plots showed higher leaf damage. Koocheki *et al.,* (2008) showed that intercropping with marigold and common rosemary induced a significant ($p < 0.05$) reduction in tomato early blight caused by *A. solani*, by means of two different mechanisms. The first mechanism was the allelopathic effects of marigold. The second way was by altering the microclimatic conditions around the canopy, particularly by reducing the number of hours per day with relative humidity >92 %, thus diminishing conidial development (Santos *et al.,* 2000). Demagnante and Vander Zaag (cited by Potts, 1990) showed also a reduced severity of attack by *A. solani* in potato when intercropped with maize, and in tomato intercropped with maize, either in single or double rows. Suman *et al*. (2000) registered less leaf damage caused by *S. lycopersici*. Among the fungicides tested against *A.solani,* spray with Azoxystrobin was found to reduce disease severity to the maximum extent. Arreaza and Hernandez (2001) reported low level of leaf damage due to early blight of tomato when sprayed with azoxystrobin as against mancozeb. MacDonald *et al*. (2007) also found suppressed disease severity in azoxystrobin treated plots. Strobilurin derivatives, such as kresoxim-methyl and azoxystrobin, have demonstrated enhanced greening of treated foliage, which has often translated into increases in yield potential (Grossamn and Retzlaff, 1997; Wu and von Tiedemann, 2001). Our study also demonstrated treatment with azoxystrobin yielded higher fruit production as compare with other treatments. Thus individually when these methods contribute significantly in managing early blight of tomato, we have integrated them to manage the disease more effectively.

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