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# Integrated management of *Colletotrichum capsici* incitant of dieback and fruit rot of chilli under temperate conditions of Kashmir, India

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**Abstract**
The frequent epiphytotics of anthracnose disease in Kashmir valley witnessed during past few years and extent of the damage in form of quality and quantity of fruits has compelled to develop integrated management of the disease. The disease was managed from nursery to transplanted crop with certain stipulated treatments in nursery viz. *Trichoderma harzianum* @ 4 g $kg^{-1}$ seed, Thiram 50 WP @ 2 g $kg^{-1}$ seed and carbendazim 50 WP @ 2 g $kg^{-1}$ seed separately. Different biological and chemical treatments were used with each spray of various fungicides. The two efficient nursery treatments comprised of thiram 50 WP @ 2g/kg seed + FYM @10 q/ha and thiram 50 WP @ 2g/kg seed + vermicompost @7 q/ha were found most effective impeding the disease severity by 26.16 and 27.63 %, respectively and in the transplanted field spray of propiconazole 25 EC @ 0.1% was found to be at par (6.10 and 8.40 %) with mancozeb 50 WP @ 0.3% securing least dieback and fruit rot intensity of 6.72 and 9.55%, respectively. It can therefore be concluded that systemic fungicides proved better in controlling the disease than protectants, hence are recommended for managing the disease in the field.

**Keywords:** Chilli, *Colletotrichum capsici*, dieback, fruit rot, integrated management

## Introduction
Chilli (*Capsicum annum* L.) one of the important commercial vegetable crops is grown extensively almost throughout the world. In Kashmir, it is locally called as ‘‘Marchangun’’ and is approximately cultivated over an area of 3200 hectares with an annual fruit production of 64000 tonnes/annum (Anonymous, 2014). Chilli has many culinary advantages both in green and ripened form. Its signicance comprises numerous chemicals including volatile oils, fatty oils, capsicinoids, carotenoids, vitamins, proteins and mineral elements (Bosland and Votava, 2003) [2]. It is abundantly rich of cholesterol free, low in sodium and rich vitamin A and besides a good source of potassium, folic acid and vitamin E. Vegetable green chilli provides more vitamin C despite of other sources whereas fresh red chilli has more vitamin A (Marin *et al.*, 2004) [10]. The capsicinoids which are alkaloids make desirable economic quality for hot chilli pungent. The large amount carotenoids provide high nutritional value and the colour to chilli (Perez-Galvez *et al.*, 2003) [15].

Chilli crop is prone and vulnerable to habitat of several fungal fauna which remarkably declines production and quality of the produce. Of the various dreaded fungal diseases, dieback and fruit rot has been considered an important and ponderable major disease in the chilli growing areas (Lubna *et al.*, 2012) [9]. The Dieback and fruit rot caused by *Colletotrichum capsici* (Butler, 1918) [3] is known to cause extensive damage to this crop rendering its cultivation difficult. Fruit yield loss due to the disease has been noticed to be over 50 per cent (Smith and Crasson, 1958) [18]. The disease mainly predominates and immensely deteriorates the mature fruits, however, dieback of shoots and green mature fruit damage has also been caused. Plant pathogens develop resistance to synthetic fungicides with its continuous exposure; persistent effects of chemicals, constantly polluting our environment and through bio-magnification have become the part of human food chain. Pesticide use is also a threat to natural enemies and non-target pests. These aspects resulted in the development of some new plant disease management practices (Agrios, 2004). Biological control in combination with other methods of plant disease management provides a possible alternative to the input decrease of agrochemicals in agriculture (Lugtenberg and Bloemberg, 2004) and thereby prevents many of associated environmental and ecological problems in sustainable disease management strategy. Perusal of the literature reveals that except the evaluation of fungicides against the causal pathogen (Dhar, 1995) [4] and variability in *colletotrichum capsici* (Lubna *et al*., 2012) [9], no work has been conducted on the management of dieback and fruit

rot of chilli in Jammu and Kashmir where agro-climatic conditions are entirely different from rest of the country. The frequent epiphytotics of the disease in valley witnessed during past few years and extent of the damage inflicted by it, has necessitated us to generate basic information on integrated management of the disease.

## Material methods

### Nursery management

An experiment was conducted in randomized block design with three replications and 12 treatments during the year 2009 and 2010. FYM @ 10 q $ha^{-1}$ and vermicompost @ 7 q $ha^{-1}$ was incorporated in the soil and the raised beds were prepared, followed by irrigation and covering of beds with polythene (100 µ thick) for soil solarization during the month of April. In biological module, seeds were treated with *Trichoderma harzianum* @ 4 g $kg^{-1}$ seed and for chemical module seed was treated with Thiram 50 WP @ 2 g $kg^{-1}$ seed and carbendazim 50 WP @ 2g $kg^{-1}$ seed to soil was common practice for biological and chemical modules and sowing was done followed by irrigation.

### Field experiments

Experiments were conducted at Shalimar campus Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir. Treatments were laid out in the plots (2.4 × 3.6 $m^2$) arranged in a randomized block design (RBD). Thirty days old seedlings were planted into the field plots in rows with row/plant spacing of 35 × 45 cm with a total population of 64 plants per plot. Three replication plots were maintained for each treatment. All fungicides were applied as water based spray liquid at required concentrations. Regular cultural practices were followed as per the recommendations.

### On transplanted crop

After transplantation in the biological and chemical module the crop was treated with one spray of mancozeb 75 WP @ 0.3 % 50 WP, Copper-oxychloride 50 WP @ 0.3%, carbendazim 50 WP @ 1%, difenoconazole 25 EC @ 0.03%, propiconazole 25 EC @ 0.01%. Recommended package of practices were followed identically in all the treatments except the control during the cropping period. Fungicidal sprays were given at three phonological stages viz., pre-flowering, fruit set and maturity. Data on disease intensity was recorded 15 days after the last spray adopting the formula of Mckinney (1923) [11].

## Results

### Nursery evaluation of seed treatments and soil amendments against *Colletotrichum capsici* causing dieback of chilli

A nursery trial was laid out on Kashmir long-1 in order to control Dieback disease with seed treatments and soil amendments. Two fungicides namely Thiram 50 WP @ 2 g/kg seed, carbendazim 50 WP @ 2 g/kg seed and one biological control agent namely *Trichoderma harzianum* @ 4 g/kg seed. Two soil amendments namely vermicompost @ 7 q $ha^{-1}$ and FYM @ 10 q $ha^{-1}$ were tested. All the treatments significantly lowered disease intensity as compared to check (Table-1). The disease intensity based on mean of two years ranges from 26.16 to 37.77 per cent in comparison to 40.80 per cent in check indicating that all the fungicides and soil amendments were significantly effective in lowering the disease intensity. The least disease intensity of 26.16 per cent was recorded in $T_7$ (Thiram + FYM) which was at par with $T_6$ (Thiram + Vermicompost) with disease intensity of 27.63 per cent. The other treatments in order of their efficacy were $T_9$ (29.30) > $T_2$ (30.73%) > $T_8$ (30.95%) > $T_{11}$ (32.30%) $T_1$ (33.27%) > $T_{10}$ (33.53%) > $T_3$ (34.13%) > $T_5$ (35.73%) > $T_4$ (37.77%). Since among the various nursery treatments $T_7$ and $T_6$ were highly effective with least disease intensity, the treatments were designated as NT1 (nursery treatment one) and NT2 (nursery treatment two). Similarly, fruit rot intensity (Table-2) ranged from 31.03 to 48.03 per cent in treated plots in comparison to 51.10 per cent recorded in check. All the test fungicides and soil amendment were significantly effective in lowering the disease intensity. The least disease intensity of 31.03 per cent was recorded in $T_7$ (Thiram + FYM) which was significantly at par with T6 (Thiram + Vermicompost) having disease intensity of 32.60 per cent. These treatments were designated as $NT_1$ and $NT_2$. $T_1$ (Thiram 50 WP) and $T_9$ (Carbendazim 50 WP + FYM) though significantly at par were next best treatments exhibiting disease intensity of 34.07 and 34.50 per cent, respectively. The other treatments in decreasing order of their efficacy were $T_8$ (35.53%) > $T_2$ (37.10%) > $T_{11}$ (38.30%), $T_{10}$ (40.37%) > $T_3$ (41.63%) > $T_5$ (46.93%) > $T_4$ (48.03%).

**Table-1:** Effect of seed treatments and soil amendments on Dieback of Chilli (*Colletotrichum capsici*) in nursery

| Treatment No. | Treatment | Per cent disease intensity* | | |
|---|---|---|---|---|
| | | 1st year | 2nd year | Pooled |
| $T_1$ | Thiram 50WP @ 2g/kg seed | 28.60 | 38.00 | 33.27 |
| $T_2$ | Carbendazim 50 WP @ 2g/kg seed | 29.40 | 32.10 | 30.73 |
| $T_3$ | *Trichoderma harzianum* @ 4g/kg seed | 33.00 | 35.30 | 34.13 |
| $T_4$ | Vermicompost @ 7 q/ha | 35.60 | 39.60 | 37.77 |
| $T_5$ | FYM @ 10 q/ha | 34.00 | 37.52 | 35.73 |
| $T_6$ | Thiram 50 WP @ 2 g/kg seed + vermicompost @ 7q/ha | 26.80 | 28.45 | 27.63 |
| T7 | Thiram 50 WP @ 2 g/kg seed + FYM @ 10 q/ha | 26.18 | 26.14 | 26.16 |
| T8 | Carbendazim 50 WP @ 2 g/kg + vermicompost @ 7 q/ha | 30.65 | 29.40 | 30.95 |
| T9 | Carbendazim 50 WP @ 2g/kg seed + FYM @ 10 q/ha | 28.00 | 30.80 | 29.90 |
| T10 | *T. harzianum* @ 4g/kg seed + vermicompost @ 7 q/ha | 31.10 | 34.00 | 33.53 |
| T11 | *T. harzianum* @ 4g/kg seed + FYM @ 10q/ha | 30.80 | 33.80 | 32.30 |
| T12 | Control | 39.00 | 42.60 | 40.80 |
| CD (P≤ 0.05) | | 2.28 | 2.79 | 2.30 |

*Mean of three replicates

**Table 2:** Effect of seed treatments and soil amendments on fruit rot of Chilli (*Colletotrichum capsici*) in nursery

| Treatment No. | Treatment | Per cent disease intensity* | | |
|---|---|---|---|---|
| | | 1st year | 2nd year | Pooled |
| $T_1$ | Thiram 50WP @ 2g/kg seed | 33.00 | 35.14 | 34.07 |
| $T_2$ | Carbendazim 50 WP @ 2g/kg seed | 36.40 | 37.80 | 37.10 |
| $T_3$ | *Trichoderma harzianum* @ 4g/kg seed | 40.60 | 42.70 | 41.63 |
| $T_4$ | Vermicompost @ 7 q/ha | 47.90 | 48.20 | 48.03 |
| $T_5$ | FYM @ 10 q/ha | 45.00 | 48.60 | 46.93 |
| $T_6$ | Thiram 50 WP @ 2 g/kg seed + vermicompost @ 7q/ha | 31.20 | 34.00 | 32.60 |
| T7 | Thiram 50 WP @ 2 g/kg seed + FYM @10 q/ha | 30.00 | 32.10 | 31.03 |
| T8 | Carbendazim 50 WP @ 2 g/kg + vermicompost @ 7 q/ha | 35.10 | 36.00 | 35.53 |
| T9 | Carbendazim 50 WP @ 2g/kg seed + FYM @ 10 q/ha | 34.00 | 35.20 | 34.50 |
| T10 | *T. harzianum* @ 4g/kg seed + vermicompost @ 7 q/ha | 39.70 | 41.10 | 40.37 |
| T11 | *T. harzianum* @ 4g/kg seed + FYM @ 10q/ha | 37.65 | 39.00 | 38.30 |
| T12 | Control | 49.50 | 53.00 | 51.10 |
| CD ($P \leq 0.05$) | | 2.21 | 3.06 | 1.84 |

*Mean of three replicates

**Integrated management**

The two best nursery treatments were included in field trial for integrated management against fruit rot and Dieback disease with fungicidal sprays. Five fungicides namely mancozeb 50 WP @ 0.1 per cent, copper oxychloride 50 WP @ 0.3 per cent, carbendazim 50 WP @ 0.1 per cent, difenoconazole 25 EC @ 0.1 per cent and propiconazole 25 EC @ 0.1 per cent along with control were evaluated along and in combination. All the treatments (Table-3) evaluated and proved significantly superior compared to check. Based on the mean of two years $T_5$ ($NT_1$ + propiconazole 25 EC @ 0.1%) though at par with $T_1$ (NT1 + mancozeb 50 WP @ 0.3%) exhibiting Dieback intensity of 6.72 per cent proved significantly superior to check (39.8%). It was followed by $T_{10}$, $T_6$, $T_3$, $T_4$, $T_9$, $T_8$, $T_{15}$, $T_2$, $T_{11}$, $T_7$, $T_{13}$ and $T_{14}$ exhibiting intensity of 7.90, 8.80, 9.10, 10.85, 12.60, 12.90, 12.90, 13.55, 13.70, 15.27, 15.85 and 17.50 per cent, respectively. $T_{12}$ ($NT_0$ + carbendazim 50 WP @ 0.1%) proved least effective exhibiting disease intensity of 18.50 per cent. Further perusal of the Table-4 revealed that all the treatments proved significantly efficacious in controlling the fruit rot of chilli. $T_5$ ($NT_1$ + propiconazole 25 EC @ 0.1%) proved significantly superior exhibiting disease intensity of 8.40 per cent against 48.85 per cent recorded in check. It was followed by $T_1$ ($NT_1$ + mancozeb 50 WP @ 0.3%) exhibiting fruit rot intensity of 9.55 per cent. The other treatments in order of their efficacy were $T_{10}$ (10.13%) > $T_6$ (11.52%) > $T_3$ (11.66%) > $T_{15}$ (12.72%) > $T_4$ (12.70%) > $T_8$ (12.80%) > $T_{11}$ (13.85%) > $T_9$ (14.70%) > $T_2$ (14.80%) > $T_{13}$ (15.65%) > $T_7$ (17.80%) > $T_{14}$ (18.30%). $T_{12}$ though significantly superior than check was least effective exhibiting fruit rot intensity of 20.33 per cent. The $T_5$ ($NT_1$ + propiconazole 25 EC @ 0.1%) produced the highest production of chilli fruit (Table-5) followed by $T_1$ ($NT_1$ + mancozeb 50 WP @ 0.3%). Lowest production was recorded in $T_2$ ($NT_1$ + copper oxychloride 50 WP @ 0.1%).

**Table 3:** Effect of various seed treatments, soil amendments and fungicidal sprays on Dieback of Chilli (*Colletotrichum capsici*) under field conditions

| Treatment No. | Treatment | Per cent disease intensity* | | |
|---|---|---|---|---|
| | | 1st year | 2nd year | Pooled |
| $T_1$ | NT1 +spray of mancozeb 50 WP @ 0.3% | 7.20 | 6.30 | 6.72 |
| $T_2$ | NT1+ spray of copper oxychloride 50WP @ 0.3% | 14.00 | 13.10 | 13.55 |
| $T_3$ | NT1 +spray of carbendazim 50 WP @ 0.1% | 9.60 | 8.60 | 9.10 |
| $T_4$ | NT1 +spray of difenoconazole 25 EC @0.03% | 10.30 | 11.40 | 10.85 |
| $T_5$ | NT1 +spray of propiconazole 25 EC @0.1% | 6.40 | 5.80 | 6.10 |
| $T_6$ | NT2 +spray of mancozeb 50 WP @ 0.3% | 9.40 | 8.20 | 8.80 |
| $T_7$ | NT2+ spray of copper oxychloride 50WP @ 0.3% | 16.45 | 14.10 | 15.27 |
| $T_8$ | NT2 +spray of carbendazim 50 WP @ 0.1% | 12.20 | 13.60 | 12.90 |
| $T_9$ | NT2 +spray of difenoconazole 25 EC @0.03% | 13.00 | 12.20 | 12.60 |
| $T_{10}$ | $NT_2$ +spray of propiconazole 25 EC @0.1% | 8.80 | 7.00 | 7.90 |
| $T_{11}$ | $NT_0$ +spray of mancozeb 50 WP @ 0.3% | 14.00 | 13.40 | 13.70 |
| $T_{12}$ | $NT_0$ + spray of copper oxychloride 50WP@0.3% | 19.20 | 17.80 | 18.50 |
| $T_{13}$ | $NT_0$ +spray of carbendazim 50 WP @ 0.1% | 16.40 | 15.30 | 15.85 |
| $T_{14}$ | $NT_0$ +spray of difenoconazole 25 EC @0.03% | 17.00 | 18.00 | 17.50 |
| $T_{15}$ | $NT_0$ + spray of propiconazole 25 EC @ 0.1% | 12.80 | 13.00 | 12.90 |
| $T_{16}$ | Control | 41.00 | 38.60 | 39.80 |
| | CD ($P \leq 0.05$) | 0.40 | 0.43 | 0.46 |

*Mean of three replicates

**Table 4:** Effect of various seed treatments, soil amendments and fungicidal sprays on fruit rot of Chilli (*Colletotrichum capsici*) under field conditions

| Treatment No. | Treatment | Per cent disease intensity* | | |
|---|---|---|---|---|
| | | 1st year | 2nd year | Pooled |
| $T_1$ | NT1 +spray of mancozeb 50 WP @ 0.3% | 10.10 | 9.00 | 9.55 |
| $T_2$ | NT1+ spray of copper oxychloride 50WP @ 0.3% | 14.60 | 15.00 | 14.80 |

| | | | | |
|---|---|---|---|---|
| $T_3$ | NT1 +spray of carbendazim 50 WP @ 0.1% | 12.40 | 10.93 | 11.66 |
| $T_4$ | NT1 +spray of difenoconazole 25 EC @0.03% | 12.00 | 13.40 | 12.85 |
| $T_5$ | NT1 +spray of propiconazole 25 EC @0.1% | 9.00 | 7.80 | 8.40 |
| $T_6$ | NT2 +spray of mancozeb 50 WP @ 0.3% | 12.45 | 10.60 | 11.52 |
| $T_7$ | NT2+ spray of copper oxychloride 50WP @ 0.3% | 18.80 | 16.80 | 17.80 |
| $T_8$ | NT2 +spray of carbendazim 50 WP @ 0.1% | 14.00 | 11.60 | 12.80 |
| $T_9$ | NT2 +spray of difenoconazole 25 EC @0.03% | 15.40 | 14.00 | 14.70 |
| $T_{10}$ | $NT_2$ +spray of propiconazole 25 EC @0.1% | 11.30 | 8.96 | 10.13 |
| $T_{11}$ | $NT_0$ +spray of mancozeb 50 WP @ 0.3% | 14.90 | 12.80 | 13.85 |
| $T_{12}$ | $NT_0$ + spray of copper oxychloride 50WP@0.3% | 21.07 | 19.60 | 20.33 |
| $T_{13}$ | $NT_0$ +spray of carbendazim 50 WP @ 0.1% | 16.30 | 15.00 | 15.65 |
| $T_{14}$ | $NT_0$ +spray of difenoconazole 25 EC @0.03% | 19.50 | 17.10 | 18.30 |
| $T_{15}$ | $NT_0$ + spray of propiconazole 25 EC @ 0.1% | 14.00 | 11.45 | 12.72 |
| $T_{16}$ | Control | 50.10 | 47.60 | 48.85 |
| CD ($P \leq 0.05$) | | 0.20 | 0.18 | 0.16 |

*Mean of three replicates

**Table-5:** Effect of various seed treatments, soil amendments and fungicidal sprays on yield of chilli

| Treatment No. | Treatment | Fruit yield (q/ha) | | |
|---|---|---|---|---|
| | | 1st year | 2nd year | Pooled |
| $T_1$ | NT1 +spray of mancozeb 50 WP @ 0.3% | 81.70 | 82.90 | 82.30 |
| $T_2$ | NT1+ spray of copper oxychloride 50WP @ 0.3% | 66.80 | 69.40 | 68.10 |
| $T_3$ | NT1 +spray of carbendazim 50 WP @ 0.1% | 80.00 | 80.50 | 80.30 |
| $T_4$ | NT1 +spray of difenoconazole 25 EC @0.03% | 70.00 | 71.10 | 70.50 |
| $T_5$ | NT1 +spray of propiconazole 25 EC @0.1% | 83.60 | 85.30 | 84.40 |
| $T_6$ | NT2 +spray of mancozeb 50 WP @ 0.3% | 79.80 | 80.10 | 79.90 |
| $T_7$ | NT2+ spray of copper oxychloride 50WP @ 0.3% | 66.90 | 67.50 | 67.20 |
| $T_8$ | NT2 +spray of carbendazim 50 WP @ 0.1% | 78.20 | 79.50 | 78.80 |
| $T_9$ | NT2 +spray of difenoconazole 25 EC @0.03% | 68.20 | 69.10 | 68.60 |
| $T_{10}$ | $NT_2$ +spray of propiconazole 25 EC @0.1% | 81.80 | 82.80 | 82.30 |
| $T_{11}$ | $NT_0$ +spray of mancozeb 50 WP @ 0.3% | 76.40 | 76.70 | 76.50 |
| $T_{12}$ | $NT_0$ + spray of copper oxychloride 50WP@0.3% | 64.70 | 65.40 | 65.00 |
| $T_{13}$ | $NT_0$ +spray of carbendazim 50 WP @ 0.1% | 75.00 | 76.20 | 75.60 |
| $T_{14}$ | $NT_0$ +spray of difenoconazole 25 EC @0.03% | 65.20 | 66.40 | 64.10 |
| $T_{15}$ | $NT_0$ + spray of propiconazole 25 EC @ 0.1% | 74.90 | 77.80 | 77.30 |
| $T_{16}$ | Control | 58.90 | 59.70 | 59.30 |
| CD ($P \leq 0.05$) | | 3.26 | 4.02 | 3.49 |

*Mean of three replicates

## Discussion

Effective control of disease usually involves usually involves the use of combination of cultural control, biological, chemical control and intrinsic resistance (Wharton and Dieguez-Uribendo, 2004). The present agriculture scenario in India indicates that it is very difficult to manage insect pests and diseases without the use chemical pesticides (Singh, 1985) [17]. Biological control of *Colletotrichum* species had been suggested as early as in 1976 by Lenne and Parberry, Jeger and Jeffries (1988) [7]. *Trichoderma harzianum* tolerant to fungicides has been reported for integrated control of plant diseases (Papavizas *et al*., 1982) [13]. An experiment was also conducted to confirm the non-target effects of these systemic fungicides on chilli. Grover and Bansal (1970) found that the seed treatment with Thiram, Brassical and Bisdithane effectively eliminated the seed borne inoculum. Perane and Jio (1988) reported a combination of soil amendment, seed treatment and fungicidal sprays more effective than either of the alone. Application of fungicides proved significantly superior when used before pathogen application as against post inoculation application. Our observations are in accordance with the findings of numerous workers (Mirdha and Chowdhury, 1990) [12]. Under field conditions on nursery treatment, the disease severity was recorded in Thiram + FYM (26.16%). Similarly, fruit rot disease intensity recorded 31.03 per cent in those treatments. On integrated management, propiconazole 25 EC @ 0.1 per cent has been reported for protective and curative activity and extensively used for control of disease (Munkcols *et al.,* 2001). Fruit yield was recorded highest in $NT_1$ + propiconazole (84.40 q/ha) and least in $NT_1$ + copper oxychloride (68.10 q/ha).

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