In vivo bio-efficacy of fungicide molecules against leaf spot, fruit rot and powdery mildew diseases of Chilli

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Abstract
Foliar diseases are causes major qualitative and quantitative yield loss in chilli at both field and storage condition. Management of these foliar diseases through fungicides is much needed effort. Hence, in present investigation different fungicide molecules were evaluated against leaf spot, fruit rot and powdery mildew diseases of chilli. Among fungicides evaluated, Carbendazim 12%+ Mancozeb 63% WP @ 750 g/ha, was found most effective with least leaf spot (9.16 PDI), powdery mildew (18.63 PDI) and fruit rot severity (13.45 PDI) compared to other fungicides and untreated control. Maximum fruit yield, 20.37 Q/ha was recorded in treatment Carbendazim 12%+ Mancozeb 63% WP @ 750 g /ha which was significantly superior over rest of the treatments. The cost benefit ratio analysis of different fungicides revealed that, Carbendazim 12%+ Mancozeb 63% WP with dosage 750 g /ha (1:15.1) found to be superior over rest of the treatments.

Keywords: Leaf spot, fruit rot, powdery mildew, fungicides and C:B ratio

Introduction
Chilli (Capsicum annuum L) is an important spice cum vegetable crop. It is grown throughout the world for its green and red ripe fruits as it is a lucrative crop and form indispensable adjuvant almost in every house. Chilli fruit is used as fresh, cooked, pickled and canned in sauces and as powder for hot spices. Pungency in chilli, which is due to the presence of capsaicin, is a digestive stimulant and a cure for rheumatic troubles. Among the spices consumed in India dried chilli powder contribute the major share. Green chillies are rich source of vitamins especially vitamin A, C, B1, B2 and also rich in vitamin P (rutin), which is of immense pharmaceutical importance (Purseglove, 1977) [12]. India is the major producer, consumer and exporter of chilli in the world. In India, chilli is cultivated over an area of 775 thousand hectares with annual production of 1492 thousand metric tonnes (Anonymous, 2014) which accounts for 25% of the world production.

Chilli suffers from many diseases caused by fungi, bacteria, viruses and nematodes. Among the fungal diseases, powdery mildew, leaf spot and anthracnose or fruit rot are the most prevalent (Khodke et al., 2009) [11]. The powdery mildew caused by Leveillula taurica (Lev.) Arn. is a major constraint in chilli production in India causing heavy yield loss ranging from 14 to 30%, due to severe defoliation and reduction in photosynthesis, size and number of fruits per plant (Gohokar and Peshney, 1981) [9]. The anthracnose or ripe fruit rot caused by Colletotrichum capsici (Sydow.) Butler and Bisby, is a wide spread problem limiting the profitable cultivation and seed production throughout the major Chilli growing regions of India. By considering the seriousness of disease and the economic damage/exorbitant losses caused by the disease, the present investigation was carried out by using different fungicides for its efficacy against foliar diseases of chilli under fielded condition.

Materials and Methods
The field experiment was laid out in Randomized Block Design (RBD) with five treatments and four replications. The seeds of a local variety of Chilli (Pusa Jwala) were sown in small beds for raising nursery and 35 days old seedlings were transplanted into the field with 75 cm inter and 45 cm intra row spacing in plots measuring 5.0 m x 3.0 m. The treatments details are presented here under.
Observations on bio-efficacy of fungicides
Observations were recorded on disease incidence and fruit yield per plot and later converted into quintal per hectare basis. The data on disease incidence were recorded before spray application and 7 days after the last spray application. The first spray of fungicides was done after the first appearance of disease symptoms. The same concentrations were also followed during second and third spray applications with an interval of 15 days. Water sprayed plots served as control.

Assessment of PDI (Percent Disease Index)
To record incidence of Cercospora leaf spot and Powdery mildew diseases, 10 plants were selected randomly. Total 10 leaves per plant were examined at lower, middle and upper level for visual symptoms of diseases. To record incidence of Colletotrichum fruit rot, randomly selected three sets of fifty Chilli fruits from each plot and observed percent incidence of infected Chilli fruits. Percent disease index (PDI) was calculated by using the formula given by Wheeler (1969) [16].

Disease rating scale for Powdery mildew disease

| Rating | % leaf area infected |
|--------|---------------------|
| 0      | No infection of powdery mildew |
| 1      | 1-10% infection |
| 2      | 11-15% infection |
| 3      | 16-25% infection |
| 4      | 26-50% infection |
| 5      | > 50% infection |

Disease rating scale for leaf spot (Cercospora) and fruit rot (Colletotrichum) disease

| Rating | % leaf/fruit area covered by disease |
|--------|-------------------------------------|
| 0      | Healthy or no disease symptoms |
| 1      | Up to 5% infection |
| 2      | >5-10% infection |
| 3      | >10-25% infection |
| 4      | >25-50% infection |
| 5      | Above 50% infection |

Yield assessment
The fruit yields of Chilli were recorded after harvesting the crop at maturity and expressed in Q/ha. Cost benefit ratio was also calculated and compared with different treatments.

Statistical analysis
All the data of diseases incidence and yields were statistically analyzed by the following procedure of RBD. Calculations were made after applying the test of significance of the means. The per cent data of disease incidence was transformed to Arch sine value.

Results and Discussion

Effect of fungicides on Anthracnose or fruit rot of Chilli caused by Colletotrichum capsici

The experimental data revealed that, minimum PDI (13.45) was noticed in plot treated with foliar spray of Carbendazim 12%+ Mancozeb 63% WP @ 750 g/ha against the fruit rot of Chilli and which was significantly superior over all the treatments. Next in the order of superiority descending order was foliar spray of Mancozeb 75% WP (14.69 PDI), lower dose of SAAF (16.91 PDI), Carbendazin 50% WP (18.63 PDI) and Hexaconazole 2% SC (20.34 PDI). Maximum PDI of 41.59 was recorded in Control plot (Table 1). The results are agreement with Yadav et al. (2017) [17], they reported that, three fungicides viz., tebuconazole (0.1%), carbendazim + mancozeb (0.1%) and propiconazole(0.1%) were effective in management of chilli fruit rotpathogen (C. capsici) in the field. These fungicides were applied as seedtreatment and foliar spray. Ebkote (2005) [17] recorded that the less per cent...
incidence of anthracnose and highest dry chilli pod yield in the treatment with emcop (0.20%) which was at par with carbendazim (0.1%) and copper oxychloride (0.25%). Chauhan et al., (2014) \(^6\) reported that the minimum anthracnose disease intensity with maximum fruit yield was found in carbendazim 0.05% which was statistically at par with 0.2% mancozeb, 0.2% carbendazim + mancozeb and 0.2% copper oxychloride.

**Effect of fungicides on yield (Q/ha) of chilli**

Results revealed that all the treatments increased the dry Chilli fruit yield (in quintal per ha) with respect to control. Maximum fruit yield, 20.37 Q/ha was recorded in treatment Carbendazim 12%+ Mancozeb 63% WP @ 750 g /ha which was significantly superior over rest of the treatments. Next treatment in order of superiority was treatment Hexaconazole 2% SC (17.88 Q/ha) followed by Mancozeb 75% WP (17.08 Q/ha) and Carbendazim 50% WP (15.83 Q/ha) as compared to control plot (14.88 Q/ha) (Table 2).Results are in comparison with results findings of Basha et al. (2017) \(^3\), Gohokar and Peshney (1981) \(^9\), Sharmila (2001) \(^14\), Akhileshwari et al. (2012) \(^1\) while working with various crops.

The incremental cost benefit ratio calculated for different fungicides revealed the superiority of treatment Carbendazim 12%+ Mancozeb 63% WP with dosage 750 g /ha (1:15.1) found to be superior over rest of the treatments (Table 3).

Experimental findings revealed that, Carbendazim 12%+ Mancozeb 63% WP at 750 g/ha effectively controlled the Cercospora leaf spot, Powdery mildew and Fruit rot diseases of Chilli crop. It showed superior result compared to its solo formulations, Mancozeb 75% WP and Carbendazim 50% WP. Fungicidal treatments recorded maximum fruit yield compared to control.

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**Table 1: Effect of foliar spray of fungicides against Leaf spot, Powdery mildew and Fruit rot disease of Chilli**

| Treatment details | Dosage g or ml /ha | Percent Disease Index |
|--------------------|-------------------|-----------------------|
|                    | Before application| After 3rd spray | % Disease Control |
| Carbendazim 12%+ Mancozeb 63% WP | 750 | 4.70 (12.51) | 19.16 (17.56) | 52.78 |
|                    | After application | After 3rd spray | % Disease Control |
|                    | 7.43 (15.81) | 18.63 (25.55) | 68.26 |
| Mancozeb 75% WP | 2000 | 3.85 (11.29) | 10.83 (19.19) | 44.17 |
|                    | 6.96 (15.29) | 43.17 (41.03) | 26.46 |
| Carbendazim 50% WP | 300 | 4.28 (11.92) | 11.20 (19.55) | 42.26 |
|                    | 7.20 (15.56) | 31.80 (34.33) | 45.83 |
| Hexaconazole 2% SC | 3000 | 4.14 (11.74) | 9.74 (18.15) | 49.79 |
|                    | 6.78 (15.08) | 20.34 (26.78) | 65.35 |
|                    | 2.42 (8.90) | 1.96 (15.03) | 2.35 |
| T7- Control | - | 4.51 (12.24) | 19.40 (26.13) | |
| CD at 5% | - | - | 0.42 | -
| S. Em. ± | - | - | 0.61 | -

*Figures in parenthesis are arc sin transformed

**Table 2: Effect of foliar spray of fungicides on yield of Chilli**

| Treatments | Formulation (ml or g/ha) | Dry Chilli yield Q/ha | % yield increase over control |
|------------|--------------------------|-----------------------|------------------------------|
| Carbendazim 12%+ Mancozeb 63% WP | 750 | 20.37 | 36.89 |
| Mancozeb 75% WP | 2000 | 17.08 | 14.78 |
| Carbendazim 50% WP | 300 | 15.83 | 6.38 |
| Hexaconazole 2% SC | 3000 | 17.88 | 20.16 |
| Control | - | - | 14.88 |
| CD @5% | - | - | 1.28 |
| S. Em. ± | - | - | 0.39 |
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