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Bio-efficacy evaluation of tebuconazole 25.9% EC against fruit rot and powdery mildew diseases of chilli under the Gangetic Plains of West Bengal

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Abstract
A field experiment was carried out to evaluate the bioefficacy of Tebuconazole 25.9 % EC against fruit rot and powdery mildew of chilli its persistence, phytotoxicity and effect on residual level and fruit quality. Experimental findings indicate that efficacy of the fungicidal products of Tebuconazole (Rainbow) 25.9% EC to increase crop yield and disease management of both fruit rot and powdery mildew was observed more or less equal to Azoxystrobin 23% SC and Tebuconazole 25.9% EC (Market sample). Among the different doses of Tebuconazole (Rainbow) 25.9% EC, plants treated @ 750 ml/ha was recorded highest yield and lowest fruit rot and powdery mildew disease incidence followed by dose of 625 ml/ha. Though, the effectiveness of lower dose of Tebuconazole (Rainbow) 25.9% EC @ 500 ml/ha was comparable to standard treatments. The combined bioefficacy and residue dynamics of Tebuconazole 25.9% EC @ 500 ml/ha to 750 ml/ha for the management of fruit rot and powdery mildew in chilli and facilitate its inclusion in good agricultural package of practices.

Keywords: Bio-efficacy, tebuconazole, fruit rot, powdery mildew, chilli

Introduction

Chilli (*Capsicum annuum* L.) is an important cultivated globally spice cum vegetable crop of tropical and sub-tropical countries (Tong and Bosland, 1999) [22]. India is the major producer, consumer and exporter of chilli in the world with an area of 287.05 thousand hectare and production of 3406.0 thousand MT green pods (Anonymous, 2017) [6]. The important chilli growing states are Andhra Pradesh, Odisha, Maharashtra, West Bengal, Karnataka, Rajasthan and Tamil Nadu. India contributes one-fourth of the total quantity of chilli exported in the world (Subbaih and Jeyakumar, 2009) [18]. Majority of the commercially grown chilli varieties are susceptible to many devastating diseases like die back, fruit rot, powdery mildew, bacterial blight and murda disease which result in considerable yield loss and quality of green and red chilli fruits. Among the major fungal diseases of chilli, anthracnose, powdery mildew and leaf spot are important (Khodke *et al.*, 2009) [11]. The powdery mildew caused by *Leveillula taurica* (Lev.) Arn. is one of the devastating disease of chilli that cause significant yield losses up to 24 per cent. 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. The disease is both seed and air borne and affects seed germination and vigour to a greater extent. Fruit rot up to 32 per cent and dieback up to 29 per cent has been noticed. Seedling decay and seed rot up to 21 per cent were recorded under Central Indian conditions. Thind and Jhooty (1985) [21] reported that losses due to anthracnose of chilli varied between 66-84 per cent. The market value and nutritive value is degraded in infected fruits resulting in poor quality seeds. By considering the seriousness of diseases and the economic damage caused by the diseases, several fungicides have been recommended against anthracnose but still there is a need to widen the choice by introducing new molecules. The present investigation was carried out by using different doses of Tebuconazole 25.9% EC for its bio-effectiveness studies (based on diseases incidence) and phytotoxicity studies against fruit rot and powdery mildew diseases of chilli.

Materials and Methods

Experimental site and field growing

Field experiments was carried out between December, 2016 and May, 2017 in the research plots of All India Coordinated Research Project on Vegetable Crops, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India, situated at 23.5°N latitude and 89°E longitude at a mean sea level of 9.75m. Pure seeds of local susceptible variety (Beldanga Local) were sown in well-prepared seed bed having sandy loam soil during the 3rd week of November, 2016 at a shallow depth 5 cm apart and covered with finely sieved well rotten leaf mold. After sowing, beds were covered with straw until germination which normally takes seven to nine days and watered through watering can regularly. Nursery beds were covered with 200 µm ultraviolet (UV)-stabilized polyethylene film supported by bamboo poles with open sides to protect seedlings from rain and direct sunlight. Seedlings were hardened by withholding water 4 days before transplanting. One month old seedlings were transplanted in the main field during the 3rd week of December, 2016 following randomized complete block design with 3 replications at 50 × 50 cm spacing with 25 plants for each replication in a 2.5 m × 2.5 m plot. Standard cultural practices were followed uniformly in all the experimental plots (Chattopadhyay *et al*., 2007) [7]. Spray of systemic insecticides was done in and around the experimental area to reduce the buildup of white fly (*Bemicia tabaci* Gen.) population, the vector of pepper leaf curl virus (PepLCV).

Treatment Details

Covering of nursery bed with 200 µm ultraviolet (UV)-stabilized polyethylene film was common in all treatments.

T_1 - Spraying of Tebuconazole 25.9% EC (Rainbow) @ 500 ml ha^{-1} immediately after the first appearance of disease symptoms followed by two sprays at 10 days interval.

T_2 - Spraying of Tebuconazole 25.9% EC (Rainbow) @ 625 ml ha^{-1} immediately after the first appearance of disease symptoms followed by two sprays at 10 days interval.

T_3 - Spraying of Tebuconazole 25.9% EC (Rainbow) @ 750 ml ha^{-1} immediately after the first appearance of disease symptoms followed by two sprays at 10 days interval.

T_4 - Spraying of Tebuconazole 25.9% EC (Market sample) @ 500 ml ha^{-1} immediately after the first appearance of disease symptoms followed by two sprays at 10 days interval.

T_5 - Spraying of Tebuconazole 25.9% EC (Market sample) @ 750 ml ha^{-1} immediately after the first appearance of disease symptoms followed by two sprays at 10 days interval.

T_6 - Spraying of Tebuconazole 25.9% EC @ 500 ml ha^{-1} immediately after the first appearance of disease symptoms followed by two sprays at 10 days interval.

T_7 - Untreated control – Water spray

For phytotoxicity evaluation only- spraying of Tebuconazole 25.9% EC (Rainbow) @ 1500 ml ha^{-1} immediately after the first appearance of disease symptoms followed by two sprays at 10 days interval.

Observations Recorded

Disease Recording

Periodic observations on fruit rot and powdery mildew diseases incidence (%) before first spray, after 10 days of first and second spray and after 10 and 20 fays of third spray on randomly selected 10 leaves/fruits per plant and 3 plants per plot were recorded for treatments at Sl. 1 to 7 following standard method. Based on the data per cent reduction of disease incidence was calculated.

Phytotoxicity

Visual observations on phytotoxicity parameters viz. leaf injury on tips / surface*, wilting, vein clearing, necrosis, epinasty and hyponasty after 1, 3, 7 and 10 days of each spray were recorded for each of the treatment at Sl. No. 1 to 8. (*based on 1-10 scale: 1=0-10%, 2=11-20%, 3=21-30%, 4=31-40%, 5=41-50%, 6=51-60%, 7=61-70%, 8=71-80%, 9=81-90%, 10=91-100%).

Yield Recorded

The yield per plot was recorded at each harvest. Yield per ha was calculated on the basis of yield per plot.

Persistence and residue analysis

Sample of chilli fruits at 1, 3, 7 and 10 days after last spray and soil samples at harvest (approx. 250 g) for treatments at Sl. No. 3, 7 and 8 were collected for residue analysis.

Statistical Analysis

The data of disease incidence was transformed into their respective angular values before analysis. Data were analyzed using Statistical Analysis Systems software OP STAT.

Result and Discussion

Effects of different treatments on the incidence of fruit rot

Reactions of plants in terms of disease incidence (DI) of fruit rot differed significantly at different time interval of observation on chilli crop. All the treated plots showed comparatively lower disease incidence values from 10 days after first spray to 20 days after third spray (Table 1 and Fig.1). The final disease incidence (DI) values were found to be the lowest (10.17%) when treated with Tebuconazole (Rainbow) 25.9% EC @ 750 ml/ha followed by Tebuconazole (Rainbow) 25.9% EC @ 625 ml/ha (13.47%) and Tebuconazole (Market sample) 25.9% EC @ 750 ml/ha (16.89%) at 20 days after third spray. The maximum disease incidence (53.82%) was noticed in un-treated plots. The per cent reduction in disease incidence was maximum (81.10%) when treated with Tebuconazole (Rainbow) 25.9% EC @ 750 ml/ha over un-treated control. Chemicals are the most common and practical method to control anthracnose diseases. However, fungicide tolerance often arises quickly, if a single compound is relied upon too heavily (Staub, 1991) [17]. The fungicide traditionally recommended for anthracnose management in chilli is Manganese ethylenebis dithiocarbamate (Maneb) (Smith, 2000) [16] although it does not consistently control the severe form of anthracnose on chilli fruit. The strobilurin fungicides azoxystrobin (Quadris), trifloxystrobin (Flint), and pyraclostrobin (Cabrio) have recently been labeled for the control of anthracnose on chilli, but only preliminary reports are available on the efficacy of these fungicides against the severe form of the disease (Alexander, 2002) [4]. The strobilurin fungicides represent important class of chemicals for the management of a broad range of fungal diseases in agricultural production systems. Sudaravadana *et al*. (2007) [20] found that treating trees with these *viz*., 1, 2 and 4 ml/l. concentrations provided 100 and more than 60 per cent reduction of panicle and leaf anthracnose compared to untreated mango trees for which disease incidences were 27.73 and 53.68 PDI. This controlling effect was mainly due to trans-laminar and systemic movement of Azoxystrobin, inside the tissues; Azoxystrobin is widely distributed from the application side by diffusion (Vincelli, 2002). [23].

Effects of different treatments on the incidence of powdery mildew

Reactions of plants in terms of disease incidence (DI) of powdery mildew differed significantly at different time interval of observation on chilli crop. All the treated plots showed comparatively lower disease incidence values from 10 days after first spray to 20 days after third spray (Table 1 and Fig. 1). The final disease incidence (DI) values were found to be the lowest (5.35%) when treated with Tebuconazole (Rainbow) 25.9% EC @ 750 ml/ha followed by Tebuconazole (Rainbow) 25.9% EC @ 625 ml/ha (6.56%) and Tebuconazole (Market sample) 25.9% EC @ 750 ml/ha (6.91%) at 20 days after third spray. The maximum disease incidence (13.39 %) was noticed in un-treated plots. The per cent reduction in disease incidence was maximum (60.02%) when treated with Tebuconazole (Rainbow) 25.9% EC @ 750 ml/ha over un-treated control. For powdery mildew the lowest DSI (%) i.e. 8.56, 9.42 and 11.24%, respectively, was recorded after 1st, 2nd and 3rd spray in treatment T_4– Tebuconazole 430 SC (500 ml/ha) followed by treatment T_3– Tebuconazole 430 SC (440 ml/ ha) i.e. 9.32, 10.22 and 11.77%, respectively (Kumar *et al*., 2017) [12].

Effects of different treatments on fruit yield

The data revealed that treated plants (Table 1 and Fig. 1), in general, increased the chilli fruit yield compared with non-treated plants. Crop yield responded differently with various fungicidal products used. Plants treated with Tebuconazole (Rainbow) 25.9% EC @ 750 ml/ha recorded the maximum fruit yield (7.78 kg/plot; 12.45 q/ha) which was closely followed by Tebuconazole (Rainbow) 25.9% EC @ 625 ml/ha (7.09 kg/plot; 11.34 q/ha) and Tebuconazole (Market sample) 25.9% EC @ 750 ml/ha (6.94 kg/plot; 11.11 q/ha). Plants receiving no treatment exhibited the lowest fruit yield (3.29 kg/plot; 5.27 q/ha). Kumar *et al*. (2017) [12] reported that the maximum disease control and high green fruit yield, dry fruit yield and seed yield could be obtained from the spray with suitable concentration of fungicide Tebuconazole as compared to Benomyl. These results are in conformity with the earlier reports of Ganeshan *et al*. (2011) [9], Adinarayana *et al*. (2012) [1], Kumbhar and More (2013) [13], Ahiladevi and Prakasam (2013) [3], and Islam *et al*. (2015) [10].

Phytotoxicity

Visual observations on phytotoxicity parameters viz. leaf injury on tips/surface, wilting, vein clearing, necrosis, epinasty and hyponasty revealed that there was no phytotoxicity to chilli crop in any treatment after 1, 3, 7 and 10 days of each spray. Hence, all the treatments were non phytotoxic to chilli crop (Table 2). A number of fungicides are being routinely used for crop protection but their phytotoxic effects have been often ignored (Vyas, 1993) [24]. Curative and eradicant activity of strobilurins against several airborne pathogens have been reported by Reuveni (2001) [14] and Anesiadis *et al*. (2003) [5]. According to the fungicide resistance action committee (FRAC, 2004) [8] preventive use and a limited number of applications of strobilurins are recommended (i.e., no more than six per season or up to three sequential applications) to reduce the risk of phytotoxicity and development of fungicide resistance pathogen strains. Affourtit *et al*. (2000) [2], Sendhil Vel *et al*. (2004) [15] and Sundaravadana (2005) [19] also reported that there were no phytotoxic symptoms throughout the cropping season of grapevine and mango due to Azoxystrobin application. Findings of our field studies suggest that Azoxystrobin 25 SC is effective in reducing anthracnose disease in fruits and leaves at the concentrations of 150 and 125g *ai* ha^{-1}. No phytotoxic symptoms were recorded after spraying on the plants even at highest dose. The Azoxystrobin 25 SC on chilli anthracnose disease will increase the choice of fungicides.

Conclusion

Chilli is a crop with multiple picking nature and safety evaluation through bioefficacy and residue dynamics studies of Tebuconazole (Rainbow) 25.9% EC to increase crop yield and disease management of both fruit rot and powdery mildew was observed more or less equal to Azoxystrobin 23% SC and Tebuconazole 25.9% EC (Market sample). Among the different doses of Tebuconazole (Rainbow) 25.9% EC, plants treated @ 750 ml/ha was recorded highest yield and lowest fruit rot and powdery mildew disease incidence followed by dose of 625 ml/ha. However, the effectiveness of lower dose of Tebuconazole (Rainbow) 25.9% EC @ 500 ml/ha was comparable to standard treatments. The use of Tebuconazole 25.9% EC @ 500 ml/ha to 750 ml/ha is suggested for the control of fruit rot and powdery mildew diseases of chilli crop.

Table 1: Incidence (%) of fruit rot and powdery mildew of chilli

Treat-ment	Pre-treatment		10 days after first spray		10 days after second spray		10 days after third spray		20 days after third spray		% reduction		Yield	
	Fruit rot	Powdery mildew	Fruit rot	Powdery mildew	Fruit rot	Powdery mildew	Fruit rot	Powdery mildew	Fruit rot	Powdery mildew	Fruit rot	Powdery mildew	Kg/ plot	q/ha
T_1	3.30 (10.35)*	1.13 (4.94)	7.30 (15.64)	3.19 (10.19)	10.70 (19.03)	5.36 (13.35)	14.84 (22.60)	8.53 (16.94)	17.44 (24.65)	9.04 (17.44)	67.59 (47.77)	32.49 (18.67)	6.38	10.21
T_2	3.35 (10.45)	1.30 (5.35)	6.62 (14.88)	2.97 (9.88)	9.57 (18.00)	4.05 (11.50)	11.43 (19.75)	5.31 (13.28)	13.47 (21.51)	6.56 (14.82)	74.98 (54.42)	51.03 (30.89)	7.09	11.34
T_3	2.80 (9.37)	1.20 (5.14)	3.90 (11.27)	2.26 (8.63)	5.77 (13.81)	3.53 (10.81)	8.83 (17.25)	4.91 (12.77)	10.17 (18.57)	5.35 (13.33)	81.10 (60.66)	60.02 (37.82)	7.78	12.45
T_4	3.17 (10.19)	1.28 (5.30)	9.09 (17.52)	2.60 (9.21)	14.73 (22.54)	4.45 (12.10)	17.49 (24.70)	6.43 (14.66)	19.84 (26.44)	7.79 (16.18)	63.14 (43.98)	41.80 (24.53)	5.80	9.28
T_5	2.43 (8.91)	1.38 (6.74)	5.59 (13.65)	2.70 (9.40)	12.26 (20.47)	4.05 (11.58)	14.25 (22.16)	5.62 (13.70)	16.89 (24.26)	6.91 (15.20)	68.61 (48.61)	48.39 (29.09)	6.94	11.11
T_6	2.37 (8.73)	1.33 (5.35)	10.67 (18.98)	2.60 (9.14)	14.72 (22.53)	4.55 (12.27)	16.88 (24.21)	6.49 (14.73)	19.16 (25.91)	7.71 (16.09)	64.39 (45.10)	42.42 (24.95)	5.72	9.16
T_7	3.03 (9.89)	0.96 (4.58)	18.37 (25.31)	3.13 (10.17)	34.07 (35.65)	6.30 (14.51)	49.38 (44.65)	12.00 (20.25)	53.82 (47.20)	13.39 (21.44)	0.00 (0.00)	0.00 (0.00)	3.29	5.27
CD at 5%	0.93	1.05	3.08	1.14	3.64	1.24	3.41	2.23	3.31	2.65	-	-	1.27	2.03
CV (%)	19.51	18.26	10.22	14.27	9.34	11.67	7.58	8.19	6.84	9.02	-	-	11.49	11.49

*Bold value in parentheses indicate angular transformed

Table 2: Phytotoxicity evaluation of test products of chilli.

Treatment	Dose/ha	Phytotoxicity parameters observed (Mean observations recorded 1, 3, 7 and 10 days after each spray)					
		Leaf injury on tips/ surface*	Wilting	Vein clearing	Necrosis	Epinasty	Hyponasty
Tebuconazole 25.9% EC (Rainbow)	500 ml	1	Nil	Nil	Nil	Nil	Nil
Tebuconazole 25.9% EC (Rainbow)	625 ml	1	Nil	Nil	Nil	Nil	Nil
Tebuconazole 25.9% EC (Rainbow)	750 ml	1	Nil	Nil	Nil	Nil	Nil
Tebuconazole 25.9% EC (Market sample)	500 ml	1	Nil	Nil	Nil	Nil	Nil
Tebuconazole 25.9% EC (Market sample)	750 ml	1	Nil	Nil	Nil	Nil	Nil
Azoxystrobin 23% SC	500 ml	1	Nil	Nil	Nil	Nil	Nil
Untreated control (water only)	-	1	Nil	Nil	Nil	Nil	Nil
Tebuconazole 25.9% EC (Rainbow)	1500 ml	1	Nil	Nil	Nil	Nil	Nil

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