Karnataka J. Agric. Sci., 28(2): (220-223) 2015

Effect of fungicides on the management of die-back and fruit rot of chilli (*Capsicum annuum* L.)

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(Recevied: September, 2014 ; Accepted: April, 2015)

Abstract: Die-back and fruit rot diseases are major yield limiting factors in all chilli growing areas of India. In the present investigation, management of chilli die-back and fruit rot was carried out under rainfed ecosystem at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. Four systemic and four combi-product fungicides along with control were used for the study. Among the four systemic fungicides, difenconazole 25 EC and pyraclostrobin 20 WG at 0.1% concentration and among five combiproduct fungicides, tricyclazole 18% + mancozeb 62% WP and pyraclostrobin 5% + metiram 55% at 0.25 concentration were found effective against fruit rot and dieback disease. Highest dry chilli yield was observed with difenconazole 25 EC (8.86 q/ha) with cost benefit ratio of 2.59 which was on par with pyraclostrobin 5% + metiram 55% (8.33 q/ha, BC ratio 2.40) and tricyclazole 18% + mancozeb 62% WP (8.21 q/ha BC ratio 2.29).

Key words: Chilli, Die-back, Fruit rot, Fungicides, Management

Introduction

Chilli (*Capsicum annuum* L.) is one of the very popular spice/ vegetable crop grown worldwide, known for its medicinal and health benefiting properties. Various biotic and abiotic stresses cause immense losses to the chilli crop throughout the world. Among the biotic stresses, fruit rot caused by *Colletotrichum,* (*C. capsici, C. gloeosporioides, C. acutatum*), *Alternaria alternata* and *Fusarium* spp. (Santoshreddy *et al.,* 2014a) is the most serious disease and has national importance as it affects the crop during the early stage and continue till the harvest and causes necrosis of the tender branches (die-back) and rottening of the ripe fruits reduces marketable yield from 10 to 80 per cent (Poonpolgul and Kumphai, 2007). In the present investigation attempts were made to study the effect of four systemic (difenconazole, propiconazole, pyraclostrobin and tebuconazole) and four combi-product (pyraclostrobin + metiram, tricyclazole + mancozeb, carbendazim + mancozeb, and hxaconazole + zineb) fungicides for management of disease.

Material and methods

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. The disease can be managed under normal weather conditions with a reasonable spray program. The trial on the management of fruit rot and die-back disease of chilli was taken up using four systemic and four combi-product fungicides along with control where only insect management was done as per package of practices of UAS, Dharwad. The efficacies of four systemic (difenconazole, propiconazole, pyraclostrobin and tebuconazole) and four combi-product (pyraclostrobin + metiram, tricyclazole + mancozeb, carbendazim + mancozeb, and hexaconazole + zineb) fungicides against the management of fruit rot disease of chilli under natural endemic field condition. The study was conducted during *kharif* 2012 and 2013 at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. The seedlings of Byadgi dabbi variety were planted in plot size of 3.0 x 3.0 m with spacing 60.0 x 60.0 cm. There were nine different chemical treatments with three replications laid out in a randomized complete block design. Four sprays were taken up starting at the appearance of die-back/green fruit stage and later at 15 days interval. Die-back and fruit rot incidence and its severity was recorded. The fruit rot severity was assessed following the score chart given by Mayee and Datar (1986). Similarly, die-back severity was also recorded by referring the following 0-9 scale based on per cent branches infected in each plant as given below.

Grade	Per cent fruit area infection/ branches infected per plant	Reaction
0	0	Immune
1	1-10	Resistant
3	11 – 25	Moderately resistant
5	26 – 50	Moderately susceptible
7	51 – 75	Susceptible
9	> 75	Highly susceptible

Per cent disease incidence of fruit rot was calculated by

$$\text{Per cent diseases incidence} = \frac{\text{Number of fruits infected}}{\text{Total number of fruits examined}} \times 100$$

Per cent Disease Index was calculated to estimate the disease severity of fruit rot disease as per the formula given by Wheeler (1969).

$$\text{Fruit rot PDI} = \frac{\text{Sum of numerical disease rating}}{\text{Total no. of samples x Maximum of disease rating scale}} \times 100$$

Per cent disease incidence of die-back was calculated by

$$\text{Per cent diseases incidence} = \frac{\text{Number of plants infected}}{\text{Total number of plants examined}} \times 100$$

Die-back severity was estimated as per the formula

$$\text{Die-back PDI} = \frac{\text{Sum of numerical disease rating}}{\text{Total no. of plants x Maximum of disease rating scale}} \times 100$$

Results and discussion

During *kharif* 2012, among four systemic fungicides evaluated at 0.1% concentration, difenconazole 25 EC showed least incidence of die back (1.33 %) with 12.31 PDI which was on par with pyraclostrobin 20 WG (2.0% die back, 16.49 PDI) and propiconazole 25 EC (2.66% die back, 19.89 PDI). Least fruit rot incidence (8.31%) was observed in difenconazole 25 EC followed by pyraclostrobin 20 WG (12.26 %), whereas least fruit rot severity (7.33 PDI) was observed in pyraclostrobin 20 WG. Among four combi product fungicides tested at 0.25% concentration, pyraclostrobin 5% + metiram 55% WG showed the least incidence (1.66 %) of die back with least severity (13.83 PDI) which was on par with tricyclazole 18% + mancozeb 62% WP (1.68% die back, 14.31 PDI). Least fruit rot incidence (10.49%) was observed in tricyclazole 18% + mancozeb 62% WP, whereas least fruit rot severity (9.00 PDI) was observed in pyraclostrobin 5% + metiram 55% WG. Highest yield was observed in difenconazole 25 EC (9.15 q/ha) with benefit cost ratio of 2.66 which was on par with tricyclazole 18% + mancozeb 62% WP (8.75 q/ha, BC ratio 2.44) and pyraclostrobin 5% + metiram 55% (8.65 q/ha BC ratio 2.48) (Table 1).

During *kharif* 2013, among four systemic fungicides evaluated at 0.1% concentration, difenconazole 25 EC showed the least incidence of die back (2.47 %) with 13.47 PDI which was on par with propiconazole 25 EC (3.67% die back, 20.29 PDI) and pyraclostrobin 20 WG (3.80% die back, 17.67 PDI). Least fruit rot incidence (9.67 %) was observed in difenconazole 25 EC followed by pyraclostrobin 20 WG (12.23 %), whereas least fruit rot severity (8.50 PDI) was observed in pyraclostrobin 20 WG which was on par with difenconazole 25EC (8.67 PDI). Among four combi-product fungicides, pyraclostrobin 5% + metiram 55% WG showed the least incidence of die back (1.66 %) with least severity (13.83 PDI) which was on par with tricyclazole 18% + mancozeb 62% WP (2.67% die back, 13.51 PDI). Least fruit rot incidence (11.67 %) was observed in tricyclazole 18% + mancozeb 62% WP, whereas least fruit rot severity (10.17 PDI) observed in pyraclostrobin 5% + metiram 55% WG. Highest yield was observed in difenconazole 25EC (8.66 q/ha) with cost benefit ratio of 2.52, which was on par with pyraclostrobin 5% + metiram 55% (8.10 q/ha BC ratio 2.32) and tricyclazole 18% + mancozeb 62% WP (7.66 q/ha BC ratio 2.14) (Table 2).

Die-back and fruit rot symptoms in chilli are depicted in Plate 1. The pooled results of *kharif* 2012 and 2013 indicated that among four systemic fungicides evaluated at 0.1% concentration, difenconazole 25 EC showed the least incidence of die-back (1.93%) which was on par with propiconazole 25 EC, pyraclostrobin 20 WG and also with all combi product fungicides. Highest die-back incidence (7.00 %) was recorded in control followed by tebuconazole 25 EC (5.00%). Least die-back severity (12.88 PDI) was observed in difenconazole 25 EC which was on par with tricyclazole 18% + mancozeb 62% WP (15.41 PDI) and pyraclostrobin 5% + metiram 55% (13.50 PDI) followed by pyraclostrobin 20 WG (17.67 PDI), whereas highest die-back severity (35.38 PDI) was observed in control followed by tebuconazole 25 EC (23.65 PDI) (Table 3).

Least fruit rot incidence (8.99 %) was observed with difenconazole 25EC which was on par with tricyclazole 18% + mancozeb 62% WP (11.08 %) and pyraclostrobin 5% + metiram 55% (11.70%) and pyraclostrobin 20 WG (12.25%). The highest fruit rot incidence (21.79%) was observed in control. Least fruit rot severity (7.91 PDI) was observed in pyraclostrobin 20 WG which was on par with difenconazole 25 EC (8.18 PDI) pyraclostrobin 5% + metiram 55% (9.55 PDI). The highest fruit rot severity (53.83 PDI) was observed in control. Pyraclostrobin 20 WG showed least infection of fruit rot pathogens on chilli

Table 1. Effect of chemical fungicides against chilli fruit rot and dieback disease during *kharif* 2012

Sl. No.	Treatments	Trade name	Concen-tration (%)	Dieback incidence (%)	Dieback severity (%)	Fruit rot incidence (%)	Fruit rot severity (%)	Dry fruit yield (q/ha)	BC ratio
1.	Difenconazole 25 EC	Score 25 EC	0.1	1.33 (6.53)	12.31 (20.31)	8.31 (16.72)	7.67 (16.02)	9.15	2.66
2.	Propiconazole 25 EC	Tilt 25 EC	0.1	2.66 (9.08)	19.89 (26.47)	13.12 (21.20)	11.00 (19.32)	7.65	2.21
3.	Pyraclostrobin 20 WG	Headline 20 WG	0.1	2.0 (7.94)	16.49 (23.93)	12.26 (20.48)	7.33 (15.48)	8.30	2.31
4.	Tebuconazole 25.9 EC	Folicur 25.9 EC	0.1	4.66 (12.35)	22.90 (28.55)	15.31 (23.03)	12.00 (20.22)	7.05	2.02
5.	Hexaconazole 4% + Zineb 68% (72 WP)	Avatar 72 WP	0.25	2.33 (8.74)	18.99 (25.81)	12.56 (20.74)	9.33 (17.63)	8.05	2.27
6.	Tricyclazole 18% + Mancozeb 62% (80 WP)	Merger 80 WP	0.25	1.68 (7.33)	14.31 (22.22)	10.49 (18.89)	10.00 (18.37)	8.75	2.44
7.	Carbendazim 12%+ Mancozeb 63% (75 WP)	Saaf 75 WP	0.25	3.33 (10.49)	21.41 (27.49)	13.43 (19.71)	12.33 (20.49)	7.9	2.26
8.	Pyraclostrobin 5% + Metiram 55% (60 WG)	Cabriotop 60 WG	0.25	1.66 (7.15)	13.83 (21.80)	11.39 (21.49)	9.00 (17.30)	8.65	2.48
9.	Untreated control	-	-	6.33 (16.77)	33.33 (35.25)	20.83 (27.14)	52.30 (46.30)	3.81	1.27
S.Em.±				1.63	1.71	0.84	1.50	0.72	-
C.D. at 0.05				3.39	3.63	1.80	3.20	2.2	-

Figures in the parentheses indicate arc sine transformed values

Table 2. Effect of chemical fungicides against chilli fruit rot and dieback disease during *kharif* 2013

Sl. No.	Treatments	Trade Name	Concentration (%)	Dieback incidence (%)	Dieback severity (%)	Fruit rot incidence (%)	Fruit rot severity (%)	Dry fruit yield (q/ha)	BC ratio
1.	Difenconazole 25 EC	Score 25 EC	0.1	2.47 (9.03)	13.47 (21.52)	9.67 (18.11)	8.67 (17.11)	8.66	2.52
2.	Propiconazole 25 EC	Tilt 25 EC	0.1	3.67 (11.04)	20.29 (26.76)	14.28 (22.19)	12.45 (20.65)	6.33	1.83
3.	Pyraclostrobin 20 WG	Headline 20 WG	0.1	3.80 (11.24)	17.67 (24.84)	12.23 (20.46)	8.50 (16.94)	7.16	2.00
4.	Tebuconazole 25.9 EC	Folicur 25.9 EC	0.1	5.33 (13.35)	23.67 (29.10)	16.67 (24.09)	13.83 (21.82)	6.83	1.96
5.	Hexaconazole 4% + Zineb 68% (72 WP)	Avatar 72 WP	0.25	3.87 (11.34)	19.33 (26.07)	14.41 (22.30)	10.28 (18.69)	7.16	2.02
6.	Tricyclazole 18% + Mancozeb 62% (80 WP)	Merger 80 WP	0.25	3.93 (11.43)	15.44 (23.13)	11.67 (19.96)	12.35 (20.57)	7.66	2.14
7.	Carbendazim 12%+ Mancozeb 63% (75 WP)	Saaf 75 WP	0.25	4.77 (12.61)	22.40 (28.24)	14.33 (22.24)	13.90 (21.88)	7.12	2.04
8.	Pyraclostrobin 5% + Metiram 55% (60 WG)	Cabriotop 60 WG	0.25	2.67 (9.39)	13.51 (21.56)	12.00 (20.26)	10.17 (18.59)	8.10	2.32
9.	Untreated control	-		7.67 (16.07)	35.33 (36.46)	22.67 (28.42)	55.33 (48.04)	3.30	1.10
S.Em.±				0.99	0.68	1.13	1.23	0.93	-
C.D. at 0.05				2.96	2.03	3.38	3.70	2.78	-

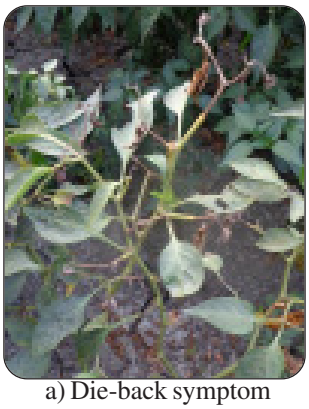
Table 3. Pooled analysis of effect of chemical fungicides against chilli fruit rot and dieback disease during 2012 and 2013

Sl. No.	Treatments	Trade Name	Concentration (%)	Dieback incidence (%)	Dieback severity (%)	Fruit rot incidence (%)	Fruit rot severity (%)	Dry fruit yield (q/ha)	BC ratio
1.	Difenconazole 25 EC	Score 25 EC	0.1	1.93 (7.99)	12.88 (20.98)	8.99 (17.44)	8.18 (16.62)	8.86	2.59
2.	Propiconazole 25 EC	Tilt 25 EC	0.1	3.13 (10.18)	20.23 (26.68)	13.73 (21.74)	11.77 (20.05)	6.95	2.02
3.	Pyraclostrobin 20 WG	Headline 20 WG	0.1	2.93 (9.86)	17.67 (24.79)	12.25 (20.48)	7.91 (16.32)	7.74	2.16
4.	Tebuconazole 25.9 EC	Folicur 25.9 EC	0.1	5.00 (12.92)	23.65 (29.06)	15.96 (23.540	12.95 (21.08)	6.93	1.99
5.	Hexaconazole 4% + Zineb 68% (72 WP)	Avatar 72 WP	0.25	3.13 (10.19)	19.33 (26.05)	13.42 (21.48)	9.82 (18.26)	7.60	2.15
6.	Tricyclazole 18% + Mancozeb 62% (80 WP)	Merger 80 WP	0.25	2.80 (9.63)	15.41 (23.10)	11.08 (19.44)	11.18 (19.53)	8.21	2.29
7.	Carbendazim 12%+ Mancozeb 63% (75 WP)	Saaf 75 WP	0.25	4.03 (11.58)	22.42 (28.16)	13.00 (21.13)	13.13 (21.24)	7.53	2.15
8.	Pyraclostrobin 5% + Metiram 55% (60 WG)	Cabriotop 60 WG	0.25	2.23 (8.59)	13.50 (21.53)	11.70 (19.99)	9.55 (17.99)	8.33	2.40
9.	Untreated control	-	-	7.00 (15.34)	35.38 (36.48)	21.79 (27.82)	53.83 (47.18)	3.58	-
S.Em.±		-	-	1.33	1.02	0.85	0.77	0.90	-
C.D. at 0.05		-	-	3.92	3.07	3.07	2.30	2.69	-

Figures in the parentheses indicate arc sine transformed values

seeds (Santoshreddy *et al.,* 2014a). Difenconazole, propiconazole and tricyclazole at 0.1% effectively managed the fruit rot diseases caused by *Colletotrichum* spp. in fruits and vegetables (Jamadar and Patil, 2007; Benagi *et al.,* 2009; Biju *et al.,* 2011; Nargund, *et al.,* 2011; Nargund, *et al.,* 2013). These are sterol inhibiting fungicides. They affect the cytochrome P-450 enzymes the inhibitors of sterol C-14 demethylation. By this they act against most of the Ascomycota group fungal pathogens, whereas strobulirins act through inhibition of respiration by binding to the Q_o center of the cytochrome b. These strobulirins have very broad and balanced spectrum of activity on the foliage and have very favorable toxicological profile rapidly dissipating from soil and surface water which are unlikely to cause hazard to non target organisms and they have both protective and curative effect (Singh, 2005).

Highest yield was observed in difenconazole 25 EC (8.86 q/ha) with cost benefit ratio of 2.59 which was on par with pyraclostrobin 5% + metiram 55% (8.33 q/ha, BC ratio 2.40) and tricyclazole 18% + mancozeb 62% WP (8.21 q/ha BC ratio 2.29), whereas lowest yield (3.58 q/ha) was observed in control.



a) Die-back symptom

b) Sunken lesions on green fruits

c) Fruit rot symptom

d) Severely infected fruits

Plate 1. Die-back and fruit rot symptoms in chilli

Among four systemic fungicides difenconazole 25 EC and pyraclostrobin 20 WG at 0.1% concentration and among five combiproduct fungicides, tricyclazole 18% + mancozeb 62% WP and pyraclostrobin 5% + metiram 55% were found effective against fruit rot and dieback disease. Use of combi-product fungicides avoids the development of resistance of fungi to systemic fungicides because these systemic fungicides interfere with only one or sometimes two functions in the physiology of fungus which it easily overcomes by either a single mutation or by selection of resistant individuals in a population. Wherein, non-systemic protectant fungicides affect too many functions in fungus physiology to develop resistance. The fungus will have to make too many gene changes. Hence, the combination of both systemic and non-systemic fungicides provides better management of plant fungal disease for long duration.

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