J. Mycopathol. Res. **59(4)** : 397-401, 2021; (ISSN 0971-3719)

Effect of fungicidal mixture on severity of Anthracnose and Powdery mildew of Chilli *vis- a- vis* meteorological factors on disease development in field

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Received : 16.07.2021 Accepted : 25.10.2021 Published : 27.12.2021

Field experiment was carried out to evaluate the performance of premix fungicide (Fluopyram 250 + Trifloxystrobin250 SC) and of individual against Anthracnose and Powdery mildew of Chilli at Farmers field, Mohanpur, Nadia, West Bengal, during kharif and rabi season, 2019. The three different doses of pre- mix fungicides of Fluopyram 250 + Trifloxystrobin 250 SC @ 200, 250 and 300 g a.i. ha^{-1} and individual of two fungicides Fluopyram 500 SC @ 150 g a.i. ha^{-1} and Trifloxystrobin 50% WG @ 150g a.i. ha^{-1} were applied in the field and observed that fungicide mixture of Fluopyram 250 + Trifloxystrobin 250 SC @ 300 g a.i. ha^{-1} significantly reduced both the diseases (4.12% and 6.88%, for Anthracnose and Powdery mildew respectively and increased yield (33.11 q ha^{-1}) in comparison to other untreated control. The progresses of both the diseases were also minimum in the above said treatment. Among the seven meteorological factors, temperature, maximum relative humidity, wind speed and bright sunshine hours were the main factors for disease progression, irrespective of different fungicide application.

Key words: Bullet, *Capsicum annum*, cash crop, *Colletotrichum capsici*, independent variables, *Leveillula taurica*, management, prediction equation.

INTRODUCTION

Chilli (*Capsicum annum* L.) has been regarded as one of the most important cash crop grown respectively under a wide range of agro climatic conditions throughout the year in India as well as in West Bengal. Major constrains for cultivation of this crop are the two diseases namely Anthracnose and Powdery mildew caused by *Colletotrichum capsici* (Syd.) Butler& Bisby and *Leveillula taurica* (Lev.) Arn. respectively, that account for serious yield losses 8-60% in all chili depending upon the varieties and environmental condition (Pandey and Pandey 2003). Chilli anthracnose causes considerable damage and accounts for losses both quantitatively and qualitatively (Anand *et al*, 2010).

At present, there are very limited strategies for the management of both the two diseases (Anthracnose and Powdery mildew) and cultivars with an adequate level of resistance are not available. Application of fungicides for the management of anthracnose as well as powdery mildew is the best option (Anand *et al*. 2010), but under high disease pressure effective control is not achieved. Over the last two decades, a lot of focus has been shifted towards developing new molecules for reducing these two diseases and several chemicals and spraying schedules have been suggested (Khodke *et al*. 2009). The objective of the present study was to study and to evaluate a pre-mixed fungicide combination against Anthracnose as well as Powdery mildew and the effect of meteorological factors for disease progression after spraying operations.

MATERIALS AND METHODS

The field experiment was conducted during kharif and rabi seasons in 2019, at Farmers field, Mohanpur, Nadia, West Bengal, India. The variety Bullet was sown in the month of May for kharif and October for rabi seasons. The seedlings of 30 days old were transplanted in the experimental plot. The plot size for each treatment was 2 x 5 m with 8 rows in each plot with 30 cm x 50 cm row to row and plant to plant distance. Fertilizers were applied @ 80: 40: 40 kg ha^{-1} in 3 split applications during planting, branching and flowering stage. The experiment

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was laid out with RBD with 4 replications and the fungicides were applied for 3 times according to the respective doses.

Two fungicides Fluopyram 250 and Trifloxystrobin 250 SC @ 150g a.i. ha^{-1} individually and three concentrations of their mixture @ 200, 250 and 300 g a.i. ha^{-1} with one check fungicide Azoxystrobin 23% SC were used. Untreated control was maintained to compare the efficacy of above fungicides and mixtures of different doses.

Fungicides were sprayed three times at 10 days intervals after initial appearance of disease (65 days) in water volume of 500 litre ha^{-1} in the field.

Disease observations were taken from individual plant by using 0- 9 scale, developed by Khodke *et al*, (2009) and then calculated as PDI (percent disease index).

$$\text{PDI }\% = \frac{\text{Sum of disease scores}}{\text{No. of observations x Highest no. in rating scale}} \text{x}100$$

The ten plants per plot per replication were selected randomly to assess the disease severity per plot (maximum rating scale 9) and all plants in a plot were harvested to compute the total yield after harvest. Data on weather factors viz. maximum temperature (T_{max}), minimum temperature (T_{min}), maximum relative humidity (RH_{max}), minimum relative humidity (RH_{min}), wind speed (WS), bright sunshine hours (BSH), and total rainfall (R_t) were collected from nearby meteorological observatory.

Seven days mean of weather parameters (independent variables) except rainfall cumulative for seven days were calculated and the prediction equation was computed out through multiple regression analysis (MRA) using SPSS computer software. Coefficient of determination (R^2) and correlation coefficient (r) were also calculated and tested for significance at 5% level of probability. Disease prediction model was developed by the following equation, Y (PDI) = a+ bixi+ e; where Y= predicted disease severity, a= intercept, bi= regression coefficient for xi, xi= independent variables (i= 1…..n weather parameters) and e= random error.

Step down multiple regression analysis was applied to disease severity data and Goodness of fit was evaluated through coefficient of determination (R^2) and standard error of estimate (Coakley *et. al.* 1988).

RESULTS AND DISCUSSION

The disease severity in the treatments including untreated check showed different reaction in two different seasons in 2019-20, though the pattern of disease development were similar in both the seasons for both the diseases and thus results were analysed and conclusion was drawn on the pooled mean of two seasons.

The two season's pooled mean showed that all the treatments reduced the disease severity significantly in comparison to untreated control. It was also observed that, two mixtures of fungicides Fluopyram 250 and Trifloxystrobin 250 SC at three different doses (@ 200, 250 and 300 g a.i. ha^{-1}) produced minimum Anthracnose and Powdery mildew disease in comparison to the individual application of these fungicides. Minimum disease was observed in the treatment of 300 g a.i. ha^{-1} (4.12% for Anthracnose and 7.88% for Powdery mildew) statistically at par with the plot sprayed with the same mixture fungicide @ 250 g ha^{-1} (5.13% for Anthracnose and 7.88% for Powdery mildew) at final date of observation (86 DAT), (Tables 1and 2). The disease progression was also minimum in these two fungicide- mixture plots in comparison to the check and individual application of the same fungicide.

In case of fruit yield (q ha^{-1}), it was observed that, all the fungicidal treatments increased the fruit yield of chilli in comparison to untreated control. Premix fungicide of Fluopyram 250 + Trifloxystrobin 250 SC (@ 300 g a.i. ha^{-1} gave the maximum yield (33.11 q ha^{-1}) followed by the same fungicide mixture @ 250 g a.i. ha^{-1} (32.46 q ha^{-1}) in comparison to individual application of these fungicides.

The results therefore indicated that pre-mix fungicide of Fluopyram250 + Trifloxystrobin 250 SC mixture @ 300 g a.i. ha^{-1} effectively and significantly reduced the anthracnose and powdery mildew disease of chilli and proportionately increased the fruit yield by controlling the disease.

The influence of environmental factors on disease progression of two different diseases were different irrespective of fungicides, sprayed in the field. The pooled analysis of individual weather variables with disease severity on Anthracnose and Powdery mildew showed that, T_{max} (r=0.600& r= 0.500 for Anthracnose and Powdery mildew respectively),

Table 1: Effect of different treatments on Powdery mildew at 65, 72, 79, 86 DAT and yield

Treatment (T)	65 DAT Kharif	65 DAT Rabi	65 DAT Poold	72 DAT Kharif	72 DAT Rabi	72 DAT Poold	79 DAT Kharif	79 DAT Rabi	79 DAT Poold	86 DAT Kharif	86 DAT Rabi	86 DAT Poold	Yield Kharif	Yield Rabi	Yield Poold
T1	3.69 (11.0)	5.00 (12.9)	4.34 (11.9)	6.33 (15.0)	6.93 (15.1)	6.63 (15.5)	8.50 (16.9)	8.53 (17.0)	8.51 (16.9)	9.45 (17.3)	10.15 (18.5)	9.80 (18.1)	31.67	29. 9	30.43
T2	3.19 (10.2)	4.98 (12.8)	4.08 (11. 5)	5.07 (13.0)	6.66 (14 .9)	5.86 (13.9)	5.64 (13.7)	8.33 (16.7)	6.98 (15.2)	6.18 (14.3)	10.00 (18.4)	8.09 (16.4)	32.18	32. 5	32.46
T3	2.87 (9.76)	5.66 (13.7)	4.26 (11.7)	3.75 (11.1)	7.47 (15.8)	5.61 (13.5)	4.49 (12.3)	9.33 (17.8)	6.91 (15. 0)	5.53 (13.5)	10.23 (1 8 .6)	7.88 (16.1)	32.55	33. 7	33.11
T4	4.25 (11.8)	5.87 (14.0)	5.06 (12.9)	6.71 (15.0)	7.13 (15.4)	6.92 (15.2)	9.09 (17.5)	9.07 (17.5)	9.08 (17.5)	10.40 (19.1)	11.12 (19.4)	10.96 (19.3)	24.88	20. 5	22.76
T5	8.73 (17. 1)	6.27 (14.4)	7.50 (15 .8)	11.25 (19.5)	8.64 (17.0)	9.94 (18.3)	14.77 (22.5)	11.35 (19.6)	13.06 (21.0)	17.89 (25.0)	13.73 (21.6)	15.81 (23.3)	23.73	21. 0	22.81
T6	5.63 (13.6)	7.67 (16.0)	6.65 (14.8)	8.39 (16.8)	9.20 (17.6)	8.79 (17.2)	10 .08 (18.5)	13.33 (21.4)	11.70 (19.9)	11.75 (20.0)	15.50 (23.1)	13.62 (21.5)	25.22	22. 2	23.72
T7	11.83 (19.8)	9.02 (17.4)	10.42 (18.6)	15.49 (23.0)	11.27 (17 .6)	13.38 (21.3)	25.65 (30.4)	20.57 (26.9)	23.11 (28.6)	27.87 (31.8)	29.66 (32.9)	28.76 (32.4)	20.67	17. 7	19.17
S E m(±)	0.89	0.55	0.63	0.78	0.23	0.81	0.65	0.32	0.46	0.51	0.42	0.59	1.12	1.22	1.13
CD (P= 0.05)	1.93	1.20	1.36	1.69	0.50	1.76	1.41	0.69	0.99	1.10	0.92	1.28	2.43	2.64	2.45

* Figures in the parenthesis are the indication of angular transformed value.

T1: Fluopyram 250 + Trifloxystrobin 250 SC @ 200g a.i./ha, T2: Fluopyram 250 + Trifloxystrobin 250 SC @ 250, g.a.i./ha, T3: Fluopyram 250 + Trifloxystrobin 250 SC@ 300g a.i./ha, T4: Fluopyram 500 SC@150g a.i./ha, T5: Trifloxystrobin 50%WG@150g a.i./ha, T6: Azoxystrobin 23% SC @ 125g a.i./ha, T7: Untreated control

Table 2: Effect of different treatments on Anthracnose severity at 65, 72, 79, 86 DAT

Treatment (T)	65 DAT Kharif	65 DAT Rabi	65 DAT Pooled	72 DAT Kharif	72 DAT Rabi	72 DAT Pooled	79 DAT Kharif	79 DAT Rabi	79 DAT Pooled	86 DAT Kharif	86 DAT Rabi	86 DAT Pooled
T1	3.38 (10.55)	2.85 (7.8 0)	3.11 (9.17)	5.91 (14.04)	3.08 (8.29)	4.49 (11.16)	7.63 (16.03)	3.52 (9.11)	5.57 (12.57)	9.92 (18.35)	7.61 (13.58)	8.76 (15.96)
T2	2.28 (8.66)	1.48 (6.97)	1.88 (7.81)	3.32 (10.19)	1.65 (7.36)	2.48 (8.71)	4. 2 5 (11.88)	1.92 (7.93)	3.08 (9.90)	5.88 (14.01)	4.38 (12.08)	5.13 (13.04)
T3	2.08 (8.2 9)	1 .28 (6.49)	1.68 (7.39)	2.13 (8.39)	1.32 (6.58)	1.72 (7.48)	2.92 (9.83)	1.40 (6.79)	2.16 (8.31)	3.68 (11.06)	4.57 (7.16)	4.12 (9.11)
T4	7.28 (15.62)	4.73 (12.52)	6.0 0 (14.07)	10.63 (19.02)	6.00 (15.32)	8.31 (17.17)	14.47 (22.35)	7.00 (17.36)	10.73 (19.85)	15.00 (22.79)	9.00 (20.99)	12.00 (21.89)
T5	4.20 (11.82)	1.95 (7.97)	3.07 (9.89)	6.74 (15.04)	2.78 (9.60)	4.76 (12.32)	10.83 (1 9.18)	3.33 (10.51)	7.08 (14.84)	13.93 (21.88)	7.98 (16.41)	10.95 (19.14)
T6	7.00 (15.32)	3.00 (8.12)	5.00 (11.72)	10.50 (18.90)	4.62 (9.31)	7.56 (14.01)	13.83 (21.83)	7.75 (12.56)	10.79 (17.19)	16.33 (23.84)	9.15 (15.05)	12.74 (19.44)
T7	11.00 (19.36)	5.08 (13.02)	8.04 (16.19)	14.53 (22.41)	9.12 (17.55)	11.82 (19.98)	20.63 (2 7.00)	14.88 (22.68)	17.75 (24.84)	26.22 (30.79)	18.10 (25.17)	22.16 (27.98)
S E m(±)	0.50	0.43	0.46	0.82	0.27	0.57	0.56	0.58	0.59	0.79	0.52	0.65
CD (P= 0 .05)	1.55	1.32	1.43	2.53	0.83	1.77	1.72	1.8 0	1.83	2.46	1.59	2.01

* Figure in the parenthesis are indication of angular transformed value.

T1: Fluopyram 250 + Trifloxystrobin 250 SC @ 200g a.i./ha, T2: Fluopyram 250 + Trifloxystrobin 250 SC @ 250, g.a.i./ha, T3: Fluopyram 250 + Trifloxystrobin 250 SC@ 300g a.i./ha, T4: Fluopyram 500 SC@150g a.i./ha, T5: Trifloxystrobin 50%WG@150g a.i./ha, T6: Azoxystrobin 23% SC @ 125g a.i./ha, T7: Untreated control

T_{min} (r=0.175& r=0.255 and BHS (r= 0.318& r= 0.178) positively, whereas RH_{max} (r= – 0.311 & r= – 0.175) and WS (r= – 0.320 & r= – 0.315) were negatively and significantly correlated with both the disease irrespective of different treatment combinations except Anthracnose, where RH_{min} (r= – 0.325) and R_t (r= – 0.188) were also negatively correlated with the above factors for disease progression. It was observed that, only T_{max} was positively and significantly influenced on pre- mix fungicide treatment of Fluopyram 250 + Trifloxystrobin 250 SC at different doses and only in individual application of Azoxystrobin sprayed plots. The other environmental parameters were positively and negatively correlated with disease progression in all treatment-combinations. It was confirmed by high significant correlation value (Table 3).

Similar studies were conducted by Guzman Plazola

Table 3: Correlation coefficient between Anthracnose, Powdery mildew and weather parameters in kharif and rabi season

Weather Parameters	Correlation coefficient	Powdery mildew	Anthracnose
Maximum Temperature (^{0}C)	"r" Value	0.500**	0.600**
	Probability	0.000	0.000
Maximum Temperature (^{0}C)	"r" Value	0.255**	0.175*
	Probability	0.003	0.040
Maximum Relative Humidity (%)	"r" Value	-0.175*	-0.311**
	Probability	0.034	0.000
Maximum Relative Humidity	"r" Value	-0.188	-0.325**
	Probability	0.055	0.000
Wind Speed	"r" Value	-0.315**	-0.320**
	Probability	0.000	0.000
Bright Sunshine Hours	"r" Value	0.178**	0.318**
	Probability	0.001	0.000
Rainfall (RF)	"r" Value	-0.124	-0.178*
	Probability	0.162	0.045
	N	128	128

* Correlation is significant at the 0.05 level.
** Correlation is significant at the 0.01 level.

et al, (2003) and their observations revealed that temperature 32°C and above coupled with very low RH reduces the spore germination of *Leveillula taurica* and progress of Powdery mildew of tomato. In chilli, Ashtaputre (2006), working with chilli Powdery mildew observed T_{max} had positive correlation and T_{min}, on Max RH and Min RH and rainfall were negatively correlated with disease development. In general, if low RH is associated with warm weather, Powdery mildew development is most rapid. The ability of Powdery mildew to spread under dry climate condition is largely due to the capacity of their conidia to disseminate of these spores and their germination at lower RH than moist condition.

In this cropping season, the T_{max} was 25^0 C, T_{min} was 15^0 - 20^0 C and cloudy weather with rainfall and RH_{max}> 85% and RH_{min}> 65% were noticed, which indicated that RH_{max}> 85%, T_{max}> 27^0 CT_{min}< 20^0 C were considered to be favourable for Anthracnose and Powdery mildew infection at a rapid development rate of 1.68% - 22.16% for Anthracnose and 4.08% - 28.76% for Powdery mildew. Step down Multiple Regression Analysis (MRA) of disease severity and weather variable showed the prediction equation for anthracnose was Y= – 43.340+ 1.653 T_{max} – 1.284 WS; R^2= 0.788 indicated that the partial regression coefficient of T_{max} and WS were significantly influenced in increase of anthracnose of chilli with a change in 1.653 units T_{max} and 1.284 units of wind speed were confirmed by high coefficient of determination value, R^2 = 0.788. Whereas, in case of Powdery mildew disease of chilli, the prediction equation showed that only T_{min}, BHS, R_t and WS were the prime important factors in disease progression. The equation was, Y= – 93.890 – 1.489WS+ 1.75 T_{max} + 2.248 T_{min}+ 5.239 BHS + 0.083 Rt + 0.339 RH_{min}; R^2= 0.865 indicated that only changing in T_{max},1.750 Units, T_{min} 2.248 units, RH_{min} 0.339 units, BHS 5.239 units, R_t 0.083 units and WS 1.489 units can predict the disease severity of powdery mildew of chilli irrespective of different fungicide applied plots. It was confirmed by high coefficient of determination value (R^2= 0.865).

It was observed that for both the diseases of Anthracnose and Powdery mildew of chilli, favourable temperature and moisture relation is important that reduces the generation time and wind speed, which helps in active liberation of conidia, dispersal of both the pathogens, *Colletotrichum capsici* and *Lavellula taurica*. It was reported by several workers in different crops (Saha and Das 2015; Mahapatra, 2016).

CONCLUSION

From the study, it may be concluded that pre-mix fungicide of Fluopyram 250 + Trifloxystrobin 250 SC mixture @ 300 g a.i. ha^{-1} can reduce the diseases of anthracnose and powdery mildew of chilli, in maximum extent as well as increase the fruit yield. Among the weather variables, maximum temperature and relative humidity for anthracnose and maximum temperature, relative humidity, bright sunshine hours, total rainfall and wind speed were considered for powdery mildew disease prediction. They directly favour the growth, multiplication, release and dispersal of conidia in crop canopy during fungicide application in field.

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