Plant Archives Vol. 25, No. 1, 2025 pp. 939-943 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.1.141

EFFECT OF A COMBINATION FUNGICIDE TRIFLOXYSTROBIN 25% + TEBUCONAZOLE 50 % - 75 WG IN TOMATO EARLY BLIGHT MANAGEMENT

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(Date of Receiving-27-11-2024; Date of Acceptance-01-02-2025)

ABSTRACT

The early blight disease is a yield limiting and economically important biotic constraint in tomato production. In this study, new generation fungicides were screened to find out the effective molecule to be applied for management of the disease in field. Of the different fungicides screened *in vitro*, the combi fungicide trifloxystrobin+ tebuconazole completely arrested the pathogen mycelial growth. The same fungicide exhibited better control of the disease in field during *kharif* 2019 and *kharif* 2020. Further, higher tomato yield and benefit cost ration was also noted with the same fungicide and hence, proving its suitability for use in combating the disease.

***Key words*:** Tomato, Early blight, Management and trifloxystrobin+ tebuconazole

Introduction

Tomato (*Solanum lycopersicum*) is important vegetable crop cultivated worldwide for its edible fruits. The crop is unique for its nutritive value being rich source of phytochemical lycopene, vitamin A, B1, B3, C, K, nicotinic acid, phosphorus, and potassium. The fruit is eaten raw in salads, used as component of numerous dishes. Further fruit is majorly used for preparation of processed products like tomato juice, ketchup, puree, paste, and dehydrated pulp. To the farmers the crop is highly remunerative and second most consumed non-starchy vegetable across the globe (Testa *et al*., 2014). It was first domesticated in Central and South America later spread to other parts of the world. Portuguese introduced it in India during 1700 (Pandey *et al*., 2003). Worldwide the crop is grown in an area of 5.51 million hectares with 186 million tonnes production and 37.10 metric tonne productivity. Further, India has an area of 0.81 million hectares under tomato cultivation with annual production of 21.17 million tonnes and productivity of 25.32 metric tonnes (Anon, 2023).

In the commercial production of tomato, the diseases possess a serious threat. Tomato early blight caused by *Alternaria solani*, *A. alternata* and other *Alternaria* spp is one of the diseases which is a prime limiting factor in its production and capable of inducing up to 78 per cent yield loss under conducive environment (Datar and Mayee 1981; Adhikari and Panthee, 2017). The causal organism is primarily air borne and to some extent it acts as soil inhabiting. Further, the disease is prevalent round the year, occurs at all crop stages and characteristically induces severe necrosis of leaf, stem, blossom leading to qualitative and quantitative loss in particular it infects fruits up to 30 per cent (Walker, 1951).

The management of early blight through host resistance has achieved meager success as the level of resistance in tomato against the disease is limited (Banerjee *et al*., 1998) which resulted in extensive use of fungicides to combat the disease. Conventional fungicides with contact/ systemic action belong to

Table 1: Details of fungicides used in the study.

Common name	Product name	Supplier	Dosage (%)	Mode of action	FRAC code
Trifloxystrobin 25 % + Tebuconazole 50 % WG	Nativo 75 WG	Bayer	0.05	QoI and ergosterol biosynthesis inhibition	1103
Azoxystrobin 8.3 %+ Mancozeb 66.7 % WG	Avancer Glow 75 WG	UPL	0.30	QoI inhibition and Multi-site contact activity	11M 03
Azoxystrobin 23% SC	Amistar 23 SC	Syngenta	0.10	QoI inhibition	11
Tebuconazole 25 EC	Folicur 25 EC	Bayer	0.10	Inhibition of ergosterol biosynthesis	03
Mancozeb75 WP	M-45 75 WP	Indofil	0.30	Multi-site contact activity	M 03

different groups are applied to control the disease but it leads to inadequate control accompanied with resistance development in pathogen population, environmental issues and lack of information on their residue levels in the crop (Patil *et al*., 2003). Thus, the new fungicide molecules with higher efficacy and safer residue levels in crop for disease management under field conditions are needed to the utmost level. With this background information the present study was conducted to identify newer fungicide molecules for management of early blight in field.

Material and Methods

Collection of *Alternaria alternata* culture

The culture of *Alternaria alternata* a pathogen causing early blight of tomato was obtained from the department of Plant Pathology, University of Horticultural Sciences, Bagalkot for *in vitro* studies.

In vitro evaluation of fungicides against *A. alternata*

Five fungicides were obtained from local market and details of them are given in Table 1. The fungicides were evaluated under *in vitro* for their inhibitory potential against pathogen at their recommended dosage through poisoned food technique using PDA medium and the plate without fungicide served as the control. The experiment was carried out in completely randomized design (CRD) with three replications for each fungicide and the whole process was repeated thrice. The mycelia growth inhibition of pathogen was noted as per the formula,

$$I = C\text{-}T/C \times 100,$$

where,

I= is percent inhibition of pathogen mycelial growth;

C= radial mycelial growth in control;

T= radial mycelial growth in treatment (Vincent (1927).

Field evaluation of fungicides against tomato early blight

Experimental location and growth conditions

For assessing the efficacy of fungicides against tomato early blight the field trials were conducted at ICAR – Krishi Vigyan Kendra, Kolar (Karnataka) for two consecutive seasons (*kharif* 2019 and *kharif* 2020). The experimental plot soil was sandy loam and susceptible tomato hybrid was raised as per the package of practice of University of Horticultural Sciences, Bagalkot (Karnataka).

Treatment imposition

The experiment was carried out in randomized block design (RBD) which consisted of five treatments and in each treatment, four replications were maintained. In each treatment two foliar sprays of fungicides were imposed at 15 days' gap and the first spray was taken up when early blight symptoms were appeared in tomato. The details of treatment were as

T1- foliar application of Trifloxystrobin 25 % + Tebuconazole 50 % – 75 WG @ 0.5 g/l;

T2 - Azoxystrobin 8.3 % + Mancozeb 66.7 % - 75 WG @ 3g/l;

Table 2: *In vitro* effect of fungicides on mycelial growth of *Alternaria alternata*.

Fungicides	Concentration (%)	Mycelial growth (cm)	Mycelial growth inhibition (%)
Trifloxystrobin + Tebuconazole	0.05	0.00	*100.00 (90.00)
Azoxystrobin + Mancozeb	0.30	0.50	94.44 (76.37)
Azoxystrobin 23% SC	0.10	1.50	83.33 (65.91)
Tebuconazole 25 EC	0.10	1.20	86.67 (68.58)
Mancozeb 75 WP	0.30	5.00	44.44 (41.81)
S.Em ±	-	0.05	0.79
CD (0.05)	-	0.15	2.37

*Mean of three replications, and figures in the parenthesis are arcsine transformed values
mycelial growth of *Alternaria alternata* in control plate is 9 cm

Table 3: Effect of fungicide spray on severity of early blight disease of tomato under field conditions.

Treatments	Dosage	Disease Index (%) at 10 days after different sprays		
		Pre spray	I spray	II spray
I season (*kharif* 2019)				
Trifloxystrobin + Tebuconazole	0.5 g	5.37 (13.40)*	11.52 (19.84)	13.07 (21.19)
Azoxystrobin + Mancozeb	3 g	5.19 (13.17)	13.89 (21.88)	15.26 (22.99)
Azoxystrobin	1 ml	4.95 (12.86)	17.48 (24.71)	22.04 (28.00)
Tebuconazole	1 ml	5.39 (13.42)	17.03 (24.37)	21.19 (27.41)
Mancozeb	3 g	4.67 (12.48)	25.78 (30.51)	32.22 (34.58)
Control	-	5.37 (13.40)	32.20 (34.57)	57.07 (49.06)
S.Em±	-	0.79	0.348	0.852
CD (0.05)	-	*NS*	0.87	2.13
II season (*kharif* 2020)				
Trifloxystrobin + Tebuconazole	0.5 g	5.09 (13.04)	10.19 (18.62)	12.03 (20.33)
Azoxystrobin + Mancozeb	3 g	5.30 (13.31)	14.01 (21.98)	15.76 (23.39)
Azoxystrobin	1 ml	4.15 (11.75)	19.48 (26.19)	24.04 (29.36)
Tebuconazole	1 ml	5.33 (13.35)	21.59 (27.69)	25.09 (30.06)
Mancozeb	3 g	4.26 (11.91)	32.22 (34.58)	41.30 (39.99)
Control	-	5.08 (13.03)	43.70 (41.38)	71.93 (58.01)
S.Em±		0.79	0.348	0.852
CD (0.05)		*NS*	0.87	2.13

*Figures in the parenthesis are arcsine transformed values *NS* – Non significant

T3 - Azoxystrobin 23 % SC @ 1 ml/l;

T4 - Tebuconazole 25 EC @ 1ml/l;

T5 – Mancozeb 75 WP @ 2.5 g/l; T6 – Control.

Disease assessment

Twenty-five plants of each replicate were marked for observations. The early blight severity in each treatment was recorded prior to initiation of experiment and after ten days of each spray. The disease severity was noted as per 0-5 scale, where 0 - No symptoms on the leaf; 1 - up to 5 per cent leaf area infected and covered by spot, no spot on petiole and branches; 2 –6 to 20 per cent leaf area infected and covered by spot, some spots on petiole; 3 –21 to 40 per cent leaf area infected and covered by spot, spots also seen on petiole, branches; 4 –41 to 70 per cent leaf area infected and covered by spot, spots also seen on petiole, braches, stem; 5 – more than 70 per cent leaf area infected and covered by spots, spots also seen on petiole, branch, stem and fruits (Datar and Mayee, 1981). The per cent disease index (PDI) was computed using the formula,

Disease index (%) = [Sum of all individual ratings/ (total no. of plants examined x maximum score)] × 100 (Wheeler, 1969).

Phytotoxicity assessment of fungicides spray and yield recording

Observations of phytotoxicity evaluation were recorded by visual observations for phytotoxicity symptoms *viz.*, leaf injury on tips/ surface, necrosis, stunting, chlorosis, vein clearing, wilting, epinasty and hyponasty at 1, 3, 5, 7 and 10 days after each spray following 0-10 scale, where: 0 = 0% phytoxicity symptoms mentioned, 1 = 1-10%, 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 of tomato fruit was recorded plot wise at each harvest and pooled data of all pickings have been presented in terms of t/ha.

Results and Discussion

Early blight caused by *Alternaria solani, A. alternata* and other *Alternaria* spp is the major limiting factor in tomato production as the disease induces severe necrosis of leaf, stem, blossom and fruit tissue under favourable field environmental conditions and leads to economic loss to the tune of 78 per cent (Datar and Mayee 1981). The level of genetic resistance in tomato to combat the disease is relatively limited (Banerjee *et al.*, 1998) and hence fungicides are the major means of management of early blight in the field (Saha *et al.*, 2014). The use of conventional fungicides resulted in limited control of the disease with environmental issues and no information on their residue levels in the crop (Patil *et al.*, 2003). Thus, the new fungicide molecules with higher efficacy and safer residue levels in tomato to combat the early blight under field conditions are need of the hour. With this need in the present study newer fungicide molecules are evaluated under *in vitro* and field conations against tomato early blight.

Table 4: Influence of fungicide spray on tomato yield.

Treatments	Yield (t/ha)		Cost Benefit Ratio (Rs.)	
	Kharif 2019	*Kharif* 2020	*Kharif* 2019	*Kharif* 2020
Trifloxystrobin +Tebuconazole	51.25	45.83	1:2.72	1:2.43
Azoxystrobin + Mancozeb	64.79	59.58	1:3.42	1:3.14
Azoxystrobin	64.17	59.17	1:3.36	1:3.10
Tebuconazole	43.33	37.08	1:2.28	1:1.95
Mancozeb	25.03	19.58	1:1.35	1:1.05
Control	18.54	14.38	1:1.01	1:0.78
S.Em±	0.958	0.376	-	-
CD (0.05)	2.39	0.94	-	-

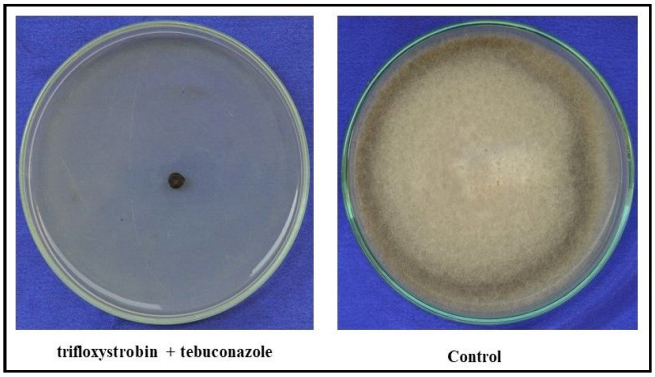

Fig. 1: Inhibition of mycelial growth of *A. alternata* by trifloxystrobin + tebuconazole.

Effect of fungicides on growth of *A. alternata* under *in vitro*

The glance of literature indicated usage of various fungicides for the management of tomato early blight. With these information five fungicides (contact, systemic and combi) were tested against *A. alternata* under *in vitro*. The complete arrest of mycelial growth was seen in combi fungicide - trifloxystrobin + tebuconazole and next best was azoxystrobin + mancozeb with 94.44 per cent mycelial inhibition (Table 2; Fig. 1). Further, tebuconazole exhibited 86.67 per cent inhibition and least effect was seen with mancozeb. The complete cessation of mycelial growth of *A. solani* and *A. alternata* by trifloxystrobin + tebuconazole (strobilurins + triazole) was evidenced by early workers under *in vitro* (Nandi *et al*., 2012; Saha *et al*., 2014). Further, individually the strobilurins and triazoles were noted to have higher efficacy against *Alternaria* spp causing early blight in tomato (Rajani and Rakholia 2012; Pondkule *et al*., 2020). Mere on *in vitro* studies the efficacy cannot be confirmed, as the evaluation is done under controlled environment wherein the only pathogen directly interacts with the test fungicide. Further, the test fungicide is not exposed to numerous field factor like variations in temperature, relative humidity and dilution factors (rain and irrigation) etc. Thus, to validate the efficacy, the fungicides were further evaluated under field conditions.

Field screening of fungicides against tomato early blight

In the field condition the combi fungicide, trifloxystrobin + tebuconazole resulted in lowest disease index (DI) at the end of the experiment in both seasons (*kharif* 2019 and *kharif* 2020) documenting 13.07 per cent and 12.03 per cent of DI in first and second season, respectively (Table 3). It was also noticed the least increase in severity of disease from beginning till end of the experiment evidencing higher effect of fungicide on

Table 5: Phytotoxicity assessment of fungicide spray on tomato crop.

Treatments	Phtotoxicity observations						
	Leaf injury on tips	Stunting	Necrosis	Chlorosis	Vein clearing	Wilting	Epinasty/ Hyponasty
I season (*kharif* 2019)							
Trifloxystrobin + Tebuconazole	-	-	-	-	-	-	-
Azoxystrobin + Mancozeb	-	-	-	-	-	-	-
Azoxystrobin	-	-	-	-	-	-	-
Tebuconazole	-	-	-	-	-	-	-
Mancozeb	-	-	-	-	-	-	-
Control	-	-	-	-	-	-	-
I season (*kharif* 2020)							
Trifloxystrobin + Tebuconazole	-	-	-	-	-	-	-
Azoxystrobin + Mancozeb	-	-	-	-	-	-	-
Azoxystrobin	-	-	-	-	-	-	-
Tebuconazole	-	-	-	-	-	-	-
Mancozeb	-	-	-	-	-	-	-
Control	-	-	-	-	-	-	-
- no phytotoxicity							

pathogen. The same fungicide was noted with higher tomato yield of 51.25 t/ha and 45.83 t/ha in first and second season, respectively as against control recording 18.54 t/ha and 14.38 t/ha. Consequently, higher the cost-benefit ratio was also recorded in the same fungicide (Table 4). Further, combi fungicide azoxystrobin + manocozeb was noted to be next best with respect to enhanced disease control and improved yield which can be employed in management of disease if more than two sprays needed. Interestingly, the individual component fungicides (azoxystrobin, tebuconazole and mancozeb) were capable to arrest the disease menace in field in both the seasons but, they performed better in combination. None of the fungicides exhibited any visible phytotoxicity symptoms at their recommended dosage in both the seasons (Table 5). The higher effect of trifloxystrobin + tebuconazole in controlling the early blight of tomato was well documented by early researchers (Saha *et al*., 2014; Pondkule *et al*., 2020; Gurudatt Hegde 2020).

Our findings documented the supremacy of the fungicides consisting of strobulurins and traizoles groups which are considered to be new generation fungicides with easy degradation leaving least residue on the tomato (Saha *et al*., 2012). The tebuconazole was found effective in suppressing the disease as it belongs to triazole group with broad spectrum activity and known to inhibit ergosterol biosynthesis by acting as demethylation inhibitor (DMI) (Capriotti *et al*., 2005). The possible mechanism for lower disease index in strobulurins treated plants would be due to inhibition of QoI (quinol oxidation site of Complex III) in mitochondrial respiration pathway thus interfering with respiration in fungi and has translaminar activity within the crop canopy there by suppressing the growth and multiplication of the fungi (Ganeshan and Chethana 2009). Comparing the individual fungicide, the combination proved more effective and reason would be synergetic effect of both triazoles as well as the strobulurins. The observations are in line with findings of Saha *et al*., (2014) and Pondkule *et al*., (2020) who also noted cumulative effect of triazoles and strobulurins in management of tomato early blight. The easy degradation of new generation fungicides will have added advantage from the point of consumers as the produce is residue free. In these lines Saha *et al*., (2014) noted below MRL level (0.48 and 1.6 mg kg^{-1} $child^{-1}$ day^{-1}) residue in trifloxystrobin + tebuconazole treated tomato fruits sampled from 0 to 7 days' post application indicating the mentioned fungicide is safe from the point of food safety. Thus, the present study highlights the higher effect of trifloxystrobin + tebuconazole against tomato early blight and hence it may be employed in management of the same under field condition.

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