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In Vivo Study of Different Compounds and Sowing Time for the Management of Turcicum Leaf Blight of Maize caused by *Exserohilum turcicum* (Pass.) Leonard and Suggs

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ABSTRACT: To identify improved control strategies for maize turcicum leaf blight (TLB) disease, including the use of different fungicides, bioagents and botanicals to decrease yield loss in the crop. Maize (*Zea mays* L.) is one of the most important food crops worldwide, along with rice and wheat, serving as a staple food, livestock feed, and industrial raw material. TLB of maize is caused by *Exserohilum turcicum* (Pass.) Leonard and Suggs, and it is one of the primary constraints in all major maize growing areas of Southern Karnataka, causing higher grain production losses in maize crops. Seed treatment and foliar spray were used to test the efficacy of eleven treatments, including bioagents, botanicals, and fungicides, in reducing TLB in susceptible maize variety CM 202. In *Kharif* and *Rabi* 2016, foliar sprays with Trifloxystrobin 25% + Tebuconazole 50% @ 0.7 g/l were found to be effective in reducing disease severity by 66.93 and 67.06 per cent, respectively, while foliar sprays with Mancozeb @ 2.5 g/l showed a 58.56 per cent reduction in disease severity in both seasons. Seed treatment + foliar spray with *Trichoderma harzianum* @ 5g/l and foliar spray with *Azadirachta indica* @ 10 per cent indicated a decrease in TLB disease severity among the bioagents and botanicals.

Keywords: Maize, turcicum leaf blight (TLB), *Exserohilum turcicum*, Fungicides, Bioagents, Management.

INTRODUCTION

Maize (*Zea mays* L.), a member of the Poaceae family, ranks with rice and wheat as one of the world's most significant food crops, serving as a staple food, livestock feed and industrial raw material (Troyer, 2006). Maize was domesticated from the wild progenitor teosinte, *Zea mays* spp. parviglumis, initially in the highlands of Mexico (Matsuoka *et al*., 2002). Globally, maize is grown under diversified environmental conditions. It is grown from 58°N to 40°S, below average sea level to altitudes higher than 3000 m and in areas with 250 mm to more than 5000 mm of rainfall per year (Dowswell *et al*., 1996). Though most of this crop is grown in the warmer parts of temperate regions and humid subtropical climates, the most lavish production is in areas with the warmest month isotherms from 21º C to 27º C and a frost free season of 120 to 180 days duration.

In an experiment, among the five fungicides, mancozeb being the most effective, followed by carbendazim and zineb, which reduce the *E. turcicum* infections on susceptible maize cultivars and increasing grain yield (Begum *et al*., 1993). The efficiency of eight fungicides in the field and discovered that foliar sprays of mancozeb (0.25 %) and maneb (0.25 %) three times at a 10-day interval were considered effective in reducing the severity of TLB of maize (Pandurangegowda *et al*., 1993). To assess the effectiveness of four neem based formulations as well as fungicides. *E. turcicum* on TLB susceptible hybrid CSH-14 was studied in the field as a seed treatment, spray or a combination of both (Bunker and Mathur, 2008). In order to suppress the disease and increase grain and fodder production, a combination of seed treatment and spray was used. A combination of mancozeb 0.25 % + *T. viride* 0.4 % + monopotassium phosphate 1 % + potassium silicate 1 % to reduce TLB was successful (Kumar *et al*., 2010).

The integration effects of varieties significantly changed the grain yield and thousand kernel weights of maize varieties with fungicides. Propiconazole treated hybrid maize variety BH-546 produced the maximum grain yield (11383 kg ha-1). TLB caused grain yield losses of up to 40.7 per cent on plots of the susceptible variety BH-543 that were not treated (Debela *et al*., 2016). The combination products Azoxystrobin 18.2 % + Difenoconazole 11.4 % SC @ 0.25 ml /l were proven to be more effective in lowering the severity of TLB. Compared to other treatments, spraying systemic fungicide Tebuconazole 250 EC @ 1.4 ml/l had the lowest disease score and the maximum grain production (Jagadeesh *et al*., 2020).

There is a need to establish solutions that simultaneously present a formidable challenge and caution while collecting information from one pathogen system to another to manage these foliar diseases in maize successfully. Several disease management techniques have been advocated to limit the incidence of maize foliar diseases, including traditional tillage that buries crop residues, crop rotation, bio extracts, bioagents, fungicide use, and planting of resistant

hybrids. As a result, it was deemed vital to design environmentally friendly disease management systems. The current study looked at fungicide, bio extracts, bioagents, and sowing time to manage TLB disease of maize.

MATERIAL AND METHODS

The experiment consists of 11 different treatments, including bioagents, botanicals, and fungicides, to know their efficacy in suppressing the disease in field conditions. These bioagents, botanicals and chemicals were sprayed at 30 DAS on highly susceptible variety CM 202, were laid out in RCBD with three replications at Zonal Agricultural Research Station, V. C, Farm, Mandya during *Kharif* and *Rabi* 2016-17. Seed treatment and spraying bioagents were done and foliar spray with bio extracts and new fungicides were carried out to know the effective method of application to control the disease. The plot size of 3 m × 3 m with 60 × 20 cm spacing with four rows of each treatment was maintained.

The TLB severity observations were recorded at the dough stage from five randomly selected plants using the 1-9 scale given by Mitiku *et al*. (2014). The disease severity was calculated. The test weight, grain yield and disease severity observations were recorded at maturity and analyzed statistically.

Effect of different sowing dates on the management of turcicum leaf blight: An experiment was conducted under field conditions during *Kharif* and *Rabi* season 2016 at Zonal Agricultural Research Station, Mandya, to study the effect of different dates of sowing on TLB severity. The trial was conducted in a randomised block design with a 4 m x 3 m plot with 60 cm x 20 cm spacing and seven replications. CM-202 highly susceptible cultivar to TLB was sown at 15 days interval from (Mid sowing dates, July 15th of *Kharif* and October 15th of *Rabi*) normal (Mid sowing) date of sowing and followed all other practices were as per package of practice recommended by UAS, Bengaluru.

Cost of cultivation (B:C ratio): The benefit cost ratio was calculated by converting plot yield to yield per hectare. The gross income of the treatments was calculated by multiplying the yield per hectare by the unit price of maize. The net benefit was obtained by subtracting the total cost of the treatment from the gross income of the treatment. Gross income was divided by total cost of treatment to calculate the benefit cost ratio. The higher the B: C ratio, the more effective the treatment.

List of treatments used for *in vivo* studies against *Exserohilum turcicum*

Sr. No.	Treatment
T_1	Seed treatment + foliar spray with *Trichoderma harzianum* @ 5g/l
T_2	Seed treatment + foliar spray with *Pseudomonas fluorescens* @ 5g/l
T_3	*Azadirachta indica* leaves @ 10%
T_4	*Lantana camara* @ 10%
T_5	Foliar spray with Trifloxystrobin 25 % + Tebuconazole 50 % @ 0.7g /l
T_6	Foliar spray with Propiconazole @ 1.0 ml/l
T_7	Foliar spray with Tebuconozole @ 1.0 ml/l
T_8	Foliar spray with Difenconozole @ 1.0 ml/l
T_9	Foliar spray with Mancozeb @ 2.5 g/l
T_{10}	Foliar spray with Carbendazim 12% + Mancozeb 63% @ 1g/l
T_{11}	Untreated control

RESULTS AND DISCUSSION

The field experiment was conducted at Zonal Agricultural Research Station, V. C. Farm Mandya during *Kharif* and *Rabi* 2016, which consists of CM 202 was used as a susceptible variety. The artificial pathogen was inoculated through the leaf whorl inoculation technique at 25 DAS. All the treatments were imposed at 30 DAS except the seed treatment and plants were sprayed with water served as control. Observations on disease severity were recorded by using 1 to 9 scale at 60 and 80 DAS. Further observations on test weight, grain yield and disease severity were recorded (Table 1, 2 and 3).

Table 1: Management of turcicum leaf blight of maize during *Kharif* 2016.

Treatments	Disease severity (%)	Disease reduction over control (%)	Grain yield (q/ha)	Test weight (g)	Net returns (Rs/ha)	B:C ratio
T_1	39.00 (6.28)	41.62 (6.51)	35.90	22.06	21055	1.57
T_2	55.00 (7.44)	17.81 (4.21)	24.00	17.98	3093	1.08
T_3	41.33 (6.46)	38.16 (6.22)	34.50	21.93	18891	1.51
T_4	47.00 (6.89)	29.74 (5.50)	29.20	20.56	10905	1.30
T_5	22.00 (4.74)	66.93 (8.22)	49.10	23.34	39229	2.02
T_6	44.00 (6.67)	34.29 (5.90)	33.60	20.68	17260	1.46
T_7	29.00 (5.43)	56.54 (7.56)	44.00	22.24	32447	1.86
T_8	36.66 (6.09)	45.15 (6.76)	40.20	22.23	25424	1.65
T_9	27.66 (5.30)	58.56 (7.69)	47.50	22.31	37891	2.01
T_{10}	45.33 (6.77)	32.23 (5.73)	32.53	20.48	15934	1.43
T_{11}	67.00 (6.28)	0.00 (0.70)	20.50	17.17	-1767	0.95
S.Em ±	**2.285**	**2.705**	**2.83**	**NS**		
CD @ 5%	**6.790**	**8.036**	**8.43**			
CV %	**9.591**	**12.243**	**13.82**			

*Figures in the parenthesis are square root transformed values

Table 2: Management of turcicum leaf blight of maize during *Rabi* 2016.

Treatments	Disease severity (%)	Disease reduction over control (%)	Grain yield (q/ha)	Test weight (g)	Net return (Rs/ha)	B:C ratio
T_1	33.33 (5.81)	43.35 (6.63)	42.50	22.21	30895	1.84
T_2	50.66 (7.15)	14.06 (3.82)	30.60	18.11	12993	1.35
T_3	35.66 (6.01)	39.47 (6.32)	41.73	22.08	29691	1.81
T_4	45.20 (6.76)	23.35 (4.88)	35.50	20.70	20340	1.55
T_5	19.33 (4.45)	67.06 (8.22)	54.00	23.50	46066	2.18
T_6	37.16 (6.13)	36.85 (6.12)	41.50	20.80	29065	1.78
T_7	26.33 (5.18)	55.16 (7.47)	48.50	22.40	39197	2.04
T_8	32.33 (5.73)	45.04 (6.76)	44.56	22.41	31957	1.82
T_9	24.33 (4.98)	58.56 (7.69)	49.36	22.50	40674	2.09
T_{10}	39.16 (6.29)	33.56 (5.84)	41.13	20.73	28805	1.78
T_{11}	59.00 (7.71)	0.00 (0.70)	25.86	17.37	6265	1.17
S.Em ±	**2.942**	**2.745**	**2.293**	**NS**		
CD @ 5%	**8.740**	**8.155**	**6.811**			
CV %	**13.926**	**12.561**	**9.594**			

Table 3: Effect of different date of sowing on turcicum leaf blight during *Kharif* and *Rabi* 2016.

Sr. No.	Treatments	*Kharif* 2016			*Rabi* 2016		
		Disease severity (%)	Grain yield (q/ha)	Test weight (g)	Disease severity (%)	Grain yield (q/ha)	Test weight (g)
T_1	Early sowing	49.52 (7.03)	29.62	22.18	46.71 (6.86)	34.64	22.32
T_2	Mid sowing	59.52 (7.71)	24.91	19.85	50.62 (7.12)	32.72	20.15
T_3	Late sowing	63.65 (7.96)	22.18	17.64	53.78 (7.35)	30.65	17.77
S.Em ±		**2.483**	**1.258**	**NS**	**1.206**	**1.203**	**NS**
CD @ 5%		**7.734**	**3.919**		**3.618**	**3.69**	
CV %		**11.409**	**13.0**		**16.0**	**9.7**	

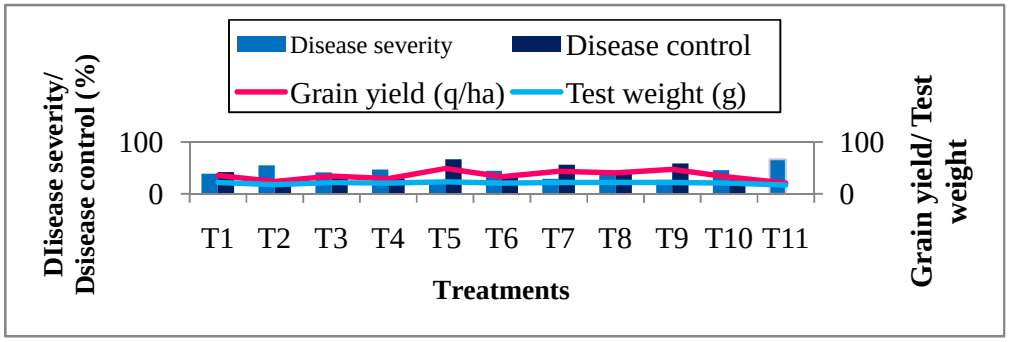

Fig. 1. Management of turcicum leaf blight of maize during *Kharif* 2016.

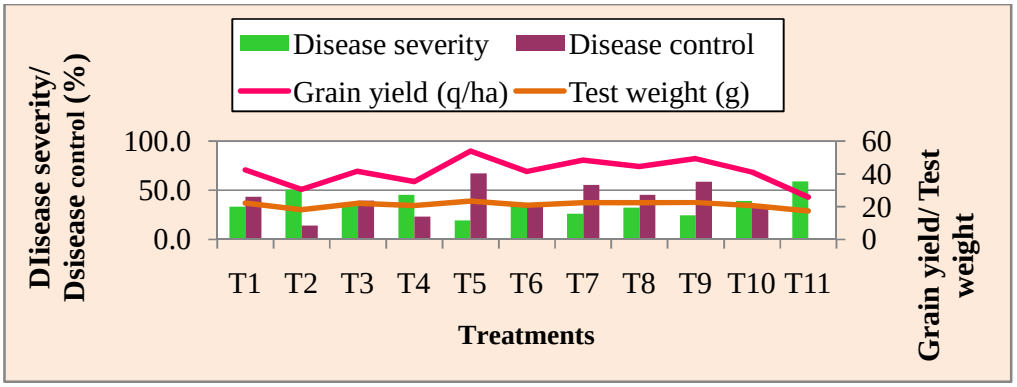

Fig. 2. Management of turcicum leaf blight of maize during *Rabi* 2016.

Effect of treatments and sowing time on disease severity during *Kharif* 2016: During *Kharif* 2016, T5 (foliar spray with Trifloxystrobin 25 % + Tebuconazole 50 % @ 0.7 g/l) and T9 (foliar spray with Mancozeb @ 2.5 g/l) treatments had the lowest disease severity of 22.00 and 27.66 per cent and the highest grain yield of 49.10 and 47.50 qha-1, as compared to control (T11) which had the highest disease severity of 67.00 per cent and the lowest grain yield of 20.5 q ha-1.

Disease severity of 29.00 per cent was recorded in T7 which is on par with T9 (foliar spray with Mancozeb @ 2.5 g/l) wherein, disease severity of 27.66 per cent

recorded. Whereas, in plots with T8 treatment (foliar spray with Difenconozole @1ml/l) recorded disease severity of 36.66 per cent, which is on par with T1 (Seed treatment+ Foliar spray with *Trichoderma harzianum* @ 5g/l) and T3 (Foliar spray with *Azadirachta indica* @ 10%) which recorded disease severity of 39.00 and 41.33 per cent respectively.

In T6 treatment (foliar spray with Propiconozole @ 1ml/l) disease severity of 44.00 per cent was on par with T3 (Foliar spray with *Azadiracta indica* @ 10%) which recorded disease severity of 41.33 per cent and it was followed by T10 (foliar spray with Carbendazim 12% + Mancozeb 63% @ 1g/l) and T4 (foliar spray with *Lantana camera* @ 10%) which recorded disease severity of 45.33 and 47.00 per cent, respectively which is on par with T6. In T2 (Seed treatment+ foliar spray with *Pseudomonas fluorescens* @ 5g/l), disease severity of 55.00 per cent was recorded.

During *Kharif* 2016, minimum disease severity of 49.52 per cent recorded in T1 (Early sowing) was significantly superior to overall treatments. It was followed by T2 (Mid sowing), which recorded a disease severity of 59.52 per cent. Maximum disease severity of 63.65 per cent was recorded in T3 (Late sowing).

The present results regarding the management of TLB disease were in accordance with the results of Anand *et al*. (2013) who reported the efficacy of Trifloxystrobin 25% + Tebuconazole 50% WG against *E. Turcicum* and opined that it reduced the incidence of leaf blight with no phytotoxic effect on plant when it is used at different concentrations and even the grain yield was recorded maximum at Trifloxistrobin 25% + Tebuconazole 50% WG.

In a study by Reddy *et al*. (2013), seven fungicides were assessed *in vitro* against *E. turcicum*, which causes TLB. Mancozeb @ 0.25 per cent and Carbendazim 12% + Mancozeb 63% @ 0.25 per cent reduce disease by 73 and 72.1 per cent, respectively.

Harlapur (2005) found that seed treatment with carboxin powder (2 g/kg) or a combination seed treatment with *Azospirillum* sp. (25 g/kg) and *T. harzianum* (6 g/kg) followed by three sprays with mancozeb (0.25%) was the most effective IDM package against TLB.

The current findings contradict those of Bindhu (2015), who investigated cultural methods in the control of TLB and found that late sowing had the lowest disease severity, followed by early sowing, and mid sowing had the highest disease severity.

Effect of treatments and sowing time on disease severity during *Rabi* 2016: During *Rabi* 2016, minimum disease severity of 19.33 per cent and maximum grain yield of 54.00 q ha^{-1} was recorded in T5 (foliar spray with Trifloxystrobin 25 % + Tebuconazole 50 % @ 0.7 g/l) which is significantly superior over all other treatments except T9 and T7 which recorded disease severity of 24.33 and 26.33 per cent with grain yield of 49.36 and 48.50 qha^{-1} respectively, as compared to control (T11) with maximum disease severity of 59.00 per cent and minimum grain yield of 25.86 q ha^{-1}

Disease severity of 26.33 per cent was recorded in T7 which is on par with T9 (foliar spray with Mancozeb @ 2.5 g/l), whereas disease severity of 24.33 per cent was recorded. Whereas T8 (foliar spray with Difenconozole @1ml/l) recorded disease severity of 32.33, which is on par with T1 (Seed treatment+ Foliar spray with *Trichoderma harzianum* @ 5g/l) and T3 (Foliar spray with *Azadirachta indica* @ 10%) which recorded disease severity of 33.33 and 35.66 per cent respectively.

During T6 treatment (foliar spray with Propiconozole @ 1ml/l) disease severity of 37.16 per cent was on par with T3 (Foliar spray with *Azadiracta indica* @ 10%) which recorded disease severity of 35.66 per cent and it was followed by T10 (foliar spray with Carbendazim 12% + Mancozeb 63% @ 1g/l) and T4 (foliar spray with *Lantana camera* @ 10%) which recorded disease severity of 39.16 and 45.20 per cent respectively, which is on par with T6. The disease severity of 50.66 per cent was recorded in T2 (Seed treatment+ foliar spray with *Pseudomonas fluorescens* @ 5g/l) which was on par with T4 (foliar spray with *Azadirachta indica*) recorded disease severity of 45.20 per cent.

During *Rabi* 2016, minimum disease severity of 46.71 per cent was recorded in T1 (Early sowing) was significantly superior over all treatments and it was followed by T2 (Mid sowing) which recorded disease severity of 50.62 per cent. Maximum disease severity of 53.78 per cent was recorded in T3 (Late sowing).

In a similar study Veerabhadraswamy *et al*. (2014) investigated the efficiency of strobilurin group fungicides against TLB and polysora rust in maize hybrids. They showed a combination of Trifloxystrobin 50 WG + Tebuconazole 250 EC @ 0.7 g/lit and a mixture of Azoxystrobin 25 SC + Difenoconazole 25 EC @ 2.5 ml/l were successful in the treatment of TLB, with a higher yield.

The results in confirmatory with Ali *et al*. (2015) found that seed treatment with Captan @ 2.5g/kg and three foliar sprays with Propiconozole @ 0.1 per cent at 30 day intervals reduced TLB disease severity while increasing grain yield by 24.2 q ac^{-1}.

The present results are not confirmatory with Bindhu (2015) results, who studied cultural practices on management of turcicum leaf blight and reported that late sowing had low disease severity followed by early sowing and highest disease severity in mid sowing.

Benefit cost ratio of treatments during *Kharif* and *Rabi* 2016: During *Kharif*, Trifloxystrobin 25 % + Tebuconazole 50 % (T5) recorded higher net returns of Rs. 39229 and higher benefit cost ratio of 2.02 followed by Mancozeb (T9) with net returns of Rs. 37891 and benefit cost ratio of 2.01, Tebuconozole (T7) with net returns of Rs. 32447 and benefit cost ratio of 1.86.

In *Rabi*, Trifloxystrobin 25 % + Tebuconazole 50 % (T5) recorded higher net returns of Rs. 46066 and high benefit cost ratio of 2.18 followed by Mancozeb (T9) with net returns of Rs. 40674 and benefit cost ratio of 2.09, Tebuconozole (T7) with net returns of Rs. 39197 and benefit cost ratio of 2.04.

Plate1: a) Pure culture on PDA, b) PDA slants, c) *E. turcicum* conidia, d) Mass multiplication on sorghum grains, e) Leaf whorl technique, f) Spraying method, g) Disease symptoms at 35 DAS, h) Disease symptoms at 80 DAS, i) and k) Control, j and l) Chemical spray with trifloxystrobin 25 % + tebuconazole 50 % in *Kharif* and *Rabi* 2016.

CONCLUSION

Foliar sprays with Trifloxystrobin 25% + Tebuconazole 50% @ 0.7 g/l effectively reduced disease severity, increased grain yield, and had a high benefit to cost ratio, followed by foliar sprays with Mancozeb @ 2.5 g/l and foliar spray with Tebuconazole @ 1ml g/l. Seed treatment combined with foliar sprays of *Trichoderma harzianum* @ 5g/l and *Azadirachta indica* @ 10 per cent reduced disease severity among bioagents and botanicals. In the susceptible inbred line CM-202, disease severity was found to be low during early and mid-sowing.

FUTURE SCOPE

Develop the most effective integrated disease management module for maize TLB.

Conflicts of interest. There are no conflicts of interest declared by the authors.

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