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Efficacy of fungicides against *Exserohilum turcicum* (Pass.) Leonard and Suggs causing turcicum leaf blight of sorghum

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Abstract
Efficacy of different non-systemic, systemic and combi-fungicides against *Exserohilum turcicum* the fungus causing turcicum leaf blight of sorghum was done employing poison food technique. The results revealed that, among the six non-systemic fungicides, mancozeb at all the concentrations gave the 100 per cent inhibition of mycelial growth. Among the seven different systemic fungicides studied, maximum inhibition of mycelial growth of 96.29, 98.44 and 98.52 per cent was noticed in Propiconazole at0.05, 0.10 and 0.15 per cent concentrations. Among the six combi-fungicides tricyclozole + mancozeb and trifloxystrobin + tebuconazole at all the concentration showed hundred per cent inhibition of mycelial growth.

Keywords: Non-systemic, systemic, Combi fungicides, turcicum leaf blight, *Exserohilum turcicum*, efficacy

Introduction
Sorghum (*Sorghum bicolor* Linn. Moench) nd ranks fifth afte popularly known as Jowar, is the major cereal consumed in India a r wheat, rice, maize and pearl millet. The world production of grain sorghum is 70.83 million tons from 44.8 million ha area of land (Faostat, 2014). India is major producer of sorghum, ranks fifth after, wheat, rice, maize and pear millet cultivated in 6.16 million hectares in both *kharif* (2.26 m. ha) and *rabi* (3.89m.ha) with an annual production of 5.44 million tons of grain with productivity of 8.44 kg per hectare (India stat, 2015).

In India the sorghum is cultivated in Maharashtra, Karnataka and Andhra Pradesh as rainfed crop to an extent of 85 per cent (4.93m.ha). In Karnataka sorghum production is about 1.32 million tons in an area of 1.04 million ha with the average productivity of 1180 kg per ha. The sorghum is the main food crop of Hyderabad-Karnataka region and occupies an area of 5.6 lakh hectares with production of 5.5 lakh tons and productivity of 1122kg per ha (Anon., 2014-15) [1].

As the *rabi* sorghum produces the white pearly grains which is mainly used for food in India for the preparation of roti. It is also an important animal feed (swine, poultry and cattle) used in countries like U.S., Mexico, South America and Australia. Sorghum, as a food, feed and bio fuel crop with excellent drought resistance compared to other cereals, is considered as a "failsafe crop" (Burke *et al*., 2010) [3].

Sorghum grain is a principal source of energy, protein, vitamins and minerals for the poor people living in the semi-arid tropics. It is nutritionally superior to rice because of its high mineral and fiber content. Starch (60-75%) is the main component of sorghum grain, followed by proteins (7-15%), non-starch polysaccharides (2-7%) and fat (1.5-6%).The average energetic value of whole sorghum grain flour is 356 kcal/100gm (Dicko *et al*., 2006) [5]. Sorghum is a good source of vitamins, notably the B vitamins (thiamin, riboflavin, pyridoxine and niacin) and the liposoluable vitamins A, D, E and K. Unique property of sorghum grain makes it well suited to prepare various food items such as porridge, unleavened bread, cookies, cakes, couscous and malted beverages, etc.

Even though the crop is robust and versatile, it has faced drawbacks in terms of yield and reduction in acreage due various diseases. The major diseases that affect sorghum include downy mildew, turcicum leaf blight, anthracnose and sorghum smuts (covered kernel smut, loose smut, long smut and head smuts). Turcicum leaf blight (TLB) is one of the most destructive foliar diseases of maize and sorghum. It can cause yield reduction more than 50 %

In susceptible varieties and is favoured by mild temperatures and humid weather conditions with heavy dews (Bergquist, 1986) [2]. The disease occurs as long elliptic tan lesions that develop on lower leaves and progress upwards. Susceptibility to *Exserohilum turcicum* is reported to decrease with crop maturity (Frederickson, 1980). Hence evaluating efficacy of fungicides against TLB will help to develop effective management practices.

Material and Methods

Poisoned food technique was followed to test the efficacy of the different fungicides. Fungicide suspension was prepared in PDA by adding required quantity to obtain the desired concentration on the basis of active ingredient and whole product present in the chemical. 20 ml of poisoned medium was poured in each of the sterilized Petri plates.

Mycelial disc of 0.5 cm was taken from the periphery of nine days old culture and was placed at the centre and incubated at 27±2 ^{0} C for nine days. Control was also maintained without addition of any fungicide, three replications were maintained for each treatment. The diameter of the colony was measured in two directions and average was worked out. The per cent inhibition of growth was calculated by using the formula given by Vincent (1927).

$$I = \frac{C - T}{C} X\ 100$$

Where

I = Per cent inhibition of mycelium

C = Growth of mycelium in control

T = Growth of mycelium in treatment

Table 1: List of non-systemic and systemic and combi fungicides evaluated against *E. turcicum*

Sl. No.	Common name	Trade name
Non-systemic fungicides		
1	Captan	Captop 70% WP
2	Copper oxychioride	Blitox 50 % WP
3	Chorothalonil	Kavach 75 %WP
4	Mancozeb	Dithane M-45 75 % WP
5	Propineb	Thiram 70% WP
6	Zineb	Dithane Z-78 75 % WP
Systemic fungicides		
1	Carbendazim	Bavistin 50% WP
2	Difenconazole	Score 25% EC
3	Hexaconazole	Contaf 5% SC
4	Propiconazole	Tilt 25% EC
5	Thiophanate methyl	Roko 70% WP
6	Triadimefon	Bayeleton 25%WP
7	Tebuconazole	Folicure 25% EC
Combi fungicides		
1	Carboxin 37.5 % + Thiram 37.5 % WS	Vitavax Power
2	Carbendazim 12 % + Mancozeb 63 % WP	SAAF
3	Tricyclazole 18 % + Mancozeb 62 % WP	Merger
4	Trifloxystrobin 25 % + Tebuconazole 50 % EC	Nativo
5	Zineb 68 % + Hexaconazole 4 % WP	Avtar
6	Captan 70 % + Hexaconazole 5 % WP	Taquat

Results and Discussion

Efficacy of non-systemic fungicides against *E. turcicum* of sorghum

Efficacy of six non systemic fungicides was tested against *E. turcicum* at different concentrations (0.1 %, 0.2 % and 0.3 %) by poisoned food technique. The results pertaining to the effect of non systemic fungicides on inhibition of *E. turcicum* are presented in Table 2.

Table 2: Efficacy of non- systemic fungicides against *E. turcicum*

Sl. No.	Fungicides	Per cent inhibition*			
		0.1%	**0.2%**	**0.3%**	**Mean**
1	Captan 70% WP	37.36 (37.68)	38.51 (38.36)	39.89 (39.17)	38.59 (38.40)
2	Copper oxychioride 50 % WP	59.78 (50.64)	60.89 (51.29)	61.90 (51.88)	45.68(51.27)
3	Chorothalonil 75 %WP	75.15 (60.10)	77.29 (61.54)	79.79 (63.28)	77.41 (61.64)
4	Mancozeb 75 % WP	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
5	Propineb 70% WP	32.97 (35.04)	34.08 (35.72)	35.15 (36.36)	34.07 (35.71)
6	Zineb 75 % WP	100.00 (90.00)	100..00 (90.00)	100.00 (90.00)	100.00 (90.00)
		S.Em±		C.D. at 1%	
Fungicide (A)		0.10		0.38	
Concentration (B)		0.07		0.27	
Fungicide x concentration (A x B)		0.17		0.66	

* Mean of three replications Figures in the parentheses are arcsine transformed values

At 0.1 per cent concentration, mancozeb and zineb resulted 100 per cent inhibition of the test fungus followed by chlorothalonil (75.15 %), copper oxychloride and (59.78%) And Captain (37.36%). Least inhibition of 32.97 per cent was found in propineb. At 0.2 per cent concentration mancozeb and zineb showed 100 per cent inhibition followed by

chlorothalonil (77.29%), copper oxychloride (61.90%) and captan (38.51%). Least inhibition of 34.08 per cent was found in propineb.

At 0.3 per cent also mancozeb and zineb showed 100 per cent inhibition followed by chlorothalonil (79.79%), copper oxychioride (60.89%) and captan (39.89%) However least inhibition of 35.15 per cent was observed in propineb.

Irrespective of fungicide concentration, mancozeb and zineb resulted 100 per cent inhibition and found to be best and stastically significantly superior over the other fungicides tested followed by chlorothalonil having mean per cent inhibition of 77.41. The results of present findings were supported by Rahman *et al*., 1993, Meli and Kulkarni, 1994, Singh and Gupta, 2000, Dharendraswamy, 2003, Harlapur *et al.,* (2007) [8] and Khedekar, 2009 who reported macozeb was most effective in inhibiting the mycelial growth of *E. turcicum* among the non-systemic fungicides evaluated while working on TLB of maize.

Efficacy of systemic fungicides against *E. turcicum*

Efficacy of seven systemic fungicides were tested against *E. turcicum* at different concentrations (0.05%, 0.10% and 0.15%) by poisoned food technique. The per cent inhibition of mycelial growth of the test fungus was calculated. The results pertaining to the effect of systemic fungicides on inhibition of *E. turcicum* are presented in Table 3.

At 0.05 per cent concentration, propiconazole (97.29%) showed the maximum inhibition of mycelial growth of the test fungus followed by tebuconazole (96.29), difenconazole (85.23%), hexaconazole (82.63%) and thiophanate methyl (72.59%) Least inhibition was found in Carbendazim and recorded 70.37 per cent.

At 0.10 per cent concentration Propiconazole and tebuconazole was found to inhibit mycelial growth of the test fungus 98.44 and 98.13 per cent respectively followed by difenconazole (88.00%), hexaconazole (84.03%) and thiophanate methyl (74.18). Least inhibition was found in carbendazim and recorded 71.86 per cent. At 0.15 per cent propiconazole and tebuconazole was found to inhibit mycelial growth of the test fungus 98.52 and 98.41 per cent respectively followed by difenconazole (89.25%), hexaconazole (85.22%) and thiophanate methyl (75.14). Least inhibition was found in carbendazim and recorded 74.03 per cent.

At all the concentrations stastically maximum inhibition was noticed in propiconazole (97.75%) but it was on par with the efficacy of tebuconazole (97.61%). However carbendazim (72.09%) was found to be the least effective among the systemic fungicides evaluated. The results of the present findings were supported by Rahman *et al*., 1993, Meli and Kulkarni, 1994, Singh and Gupta, 2000 and and Harlapur *et al.,* (2007) [8], who reported propiconazole was most effective in inhibiting the mycelial growth of *E. turcicum* among systemic fungicides evaluated while working on TLB of maize.

Table 3: Efficacy of systemic fungicides against *E. turcicum*

Sl. No.	Fungicides	Per cent inhibition*			
		0.05%	**0.10%**	**0.15%**	**Mean**
1	Carbendazim 50% WP	70.37 (57.02)	71.86 (57.96)	74.03 (59.36)	72.09 (58.12)
2	Difenconazole 25% EC	77.31 (61.55)	82.00 (64.90)	85.23 (67.40	81.51 (64.62)
3	Hexaconazole 70% WP	82.63 (65.37)	84.03 (66.45)	85.22 (67.39)	83.96 (66.40)
4	Propiconazole 5% SC	96.29 (78.92)	98.44 (82.95)	98.52 (83.11)	97.75 (81.66)
5	Thiophanate methyl 25% EC	72.59 (58.43)	74.18 (59.46)	75.14 (60.10)	73.97 (59.33)
6	Triadimefon 25% WP	80.79 (64.01)	81.86 (64.79)	83.17 (65.78)	81.94 (64.86)
7	Tebuconazole 25% EC	96.29 (78.92)	98.13 (82.23)	98.41 (82.90)	97.61 (81.3)
		S.Em±		C.D. at 1%	
Fungicide (A)		0.28		1.06	
Concentration (B)		0.18		0.69	
Fungicide x concentration (A x B)		0.48		1.83	

* Mean of three replications Figures in the parentheses are arcsine transformed values

Efficacy of combi fungicides against *E. turcicum* of sorghum

The results pertaining to the effect of combi fungicides on inhibition of *E. turcicum* are presented in Table 4. All the fungicides were effective in inhibiting the mycelial growth of test fungus at different concentrations (0.1%, 0.2% and 0.3%).

At 0.1 per cent concentration, tricyclozole + mancozeb and trifloxystrobin + tebuconazole showed 100 per cent inhibition followed by carboxin +thiram (99.30%) and carbendazim + mancozeb (97.38%). Least inhibition was found in captan + hexaconazole (90.82%) and zineb + hexaconazole (89.79%).

At 0.2 per cent concentration, tricyclozole + mancozeb and trifloxystrobin + tebuconazole completely inhibited the mycelial growth. However carboxin + thiram inhibited mycelial growth of 99.13 per cent followed by carbendazim + mancozeb 98.41 per cent. At 0.3 per cent concentration also tricyclozole + mancozeb and trifloxystrobin + tebuconazole showed the 100 per cent inhibition and least inhibition was found in zineb + hexaconazole (91.93%).

Among the combi fungicides tested, tricyclozole + mancozeb and trifloxystrobin + tebuconazole at all the concentration showed hundred per cent mean inhibition. The least effectiveness was found in zineb + hexaconazole with 90.85 mean per cent inhibition. The results of the present study was supported by Rahman *et al*., 1993, Meli and Kulkarni, 1994, Harlapur *et al.,* (2007) [8] and Khedekar, 2009 who reported carboxin + thiram was most effective in inhibiting the mycelial growth of *E. turcicum* among the combi fungicides evaluated while working on TLB of maize.

Table 4: Efficacy of combi fungicides against *E. turcicum*

Sl. No.	Fungicides	Per cent inhibition*			
		0.1%	0.2%	0.3%	Mean
1	Carboxin 37.5 % +Thiram 37.5%	99.30 (85.71)	99.45 (86.40)	100.00 (90.00)	99.58 (87.37)
2	Carbendazim 12% + Mancozeb 63%WP	97.38 (80.73)	98.41 (82.91)	100.00 (90.00)	98.60 (84.54)
3	Tricyclozole 18% + Mancozeb 62%WP	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
4	Trifloxystrobin 25% + Tebuconazole 50%EC	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
5	Zineb 68% + Hexaconazole 4%WP	89.79 (71.36)	90.82 (72.37)	91.93 (73.50)	90.85 (72.41)
6	Captan 70% + Hexaconazole 5%WP	90.82 (72.37)	91.96 (73.54)	92.00 (73.57)	91.60 (73.16)
		S.Em±		C.D. at 1%	
Fungicide (A)		0.36		1.38	
Concentration (B)		0.25		0.97	
Fungicide x concentration (A x B)		0.62		2.38	

* Mean of three replications Figures in the parentheses are arcsine transformed values

Conclusions

Among the six non systemic fungicides evaluated mancozeb and zineb resulted 100 per cent inhibition. Among the seven systemic fungicides evaluated, maximum inhibition was observed in propiconazole (97.75%). Among the combi fungicides tested, tricyclozole + mancozeb and trifloxystrobin + Tebuconazole showed 100 per cent inhibition.

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