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The efficacy of fungicides against post flowering stalk rot (PFSR) of specialty corn caused by *Fusarium verticillioides* (Sheldon)

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Abstract
Three Systemic fungicides were evaluated against four isolates (Fv SC-01 to Fv SC-04) of *Fusarium verticillioides in vitro* condition to develop effective management strategies for post flowering stalk rot (PFSR) of specialty corn caused by *F. verticillioides*. Bavistin and saaf were found most effective inhibited 100% mycelial growth of pathogen *in vitro* at different concentrations@ 200, 400 and 600 ppm. Tebuconazole also showed complete inhibition of the mycelial growth at 400 and 600 ppm concentration, while at 200 ppm concentration it caused 97.80, 98.0, 98.33 and 98.55 per cent inhibition (Fv SC-01, 02, 03 and 04) of all isolates respectively.

Keywords: *Fusarium verticillioides*, fungicide, *in vitro* and specialty corn

1. Introduction
The specialty corn has gained an important status and area under Popcorn, Baby corn, Sweet corn and QPM is increasing because of high net returns. The popcorn is nutritionally rich food (Kumar *et al.*, 2012) [4]. Due to its immense nutritionally rich food value and high remunerative commercial value, cultivation of pop com is another choice of farmers now a day. Sweet corn is a hybridized variety of maize specifically bred to increase the sugar content (Wikipedia, 2016). A sweetness breakthrough was accomplished with the discovery of the shrunken (sh-2) gene. "Baby corn" is the immature cob used for table purpose as a salad or cooked as vegetable. Post Flowering Stalk Rot (PFSR) is one of the most serious, destructive and wide spread diseases of Maize especially most of the specialty corn hybrids are highly susceptible. In recent years the production of specialty corn has gone up to greater heights. This has been hampered by PFSR in most of these specialty corn hybrids. In the year 2013 and 2014 during *Kharif* several fields were totally finished because of PFSR and farmers were at loss. Last year *i.e.*; *Kharif*-2014 in Madar village three fields each of more than one hectare, where severely infested due to this disease and they could harvest hardly 30-35% of healthy sweet corn cobs form the fields (Anonymous, 2014) [1]. Fungicides play a vital role in disease management in various crop ecosystems, but much information is not available against PFSR especially in relation to specialty corn. Being soil borne, *Fusarium verticillioides* are randomly distributed in the soil and are difficult to control by single control strategy. Therefore, it is planned to develop effective management strategies to manage PFSR using fungicides in specialty corn under *in vitro* conditions.

2. Materials and Methods
The experiment was conducted at Department of Plant Pathology, Rajasthan College of Agriculture (RCA) MPUAT, Udaipur during *Kharif* 2015-16.
Three systemic fungicides *viz.* Saaf [Carbendazim 12%+Mancozeb 63%WP] United Phosphorus Limited Vapi, Bavistin 50% WP [Carbendazim, Methyl-2 benzimidazolecarbamate (MBC)] BASF India Ltd., Mumbai, Tebuconazole 5.36% (w/w) FS [1-(4-Chlorophenyl)-4,4-dimethyl-3-(1,2,4-triazol-1-methyl) pentan-3-ol (Folicur 250 EC) Bayer Crop Science, India Ltd., Mumbai, were evaluated *in vitro* against *F. verticillioides* by employing poison food technique suggested by Nene and Thapaliyal, 1993 [6] with three concentrations *viz*. 200, 400 and 600 ppm with four replications of each. The calculated quantities of fungicides were thoroughly mixed in the luke warm media, almost cool PDA

medium before pouring into Petri-plates so as to get the desired concentration of each fungicide separately. The plates were aseptically inoculated with 5 mm disc cut from the periphery of 7 days old actively growing culture of *F. verticillioides* and controls without fungicides were maintained for comparison. The experiments were conducted in completely randomized design with four replications in each treatment and the inoculated plates were incubated at 25 ± 2 °C. The colony diameter or radial growth was measured after 7 days when the control plates were full of fungal growth. Per cent inhibition of mycelial growth was calculated by using formula given by Bliss, (1934) [2].

$$I = \frac{C - T}{C} x100$$

Where,
I = Per cent inhibition
C = Colony diameter in control;
T = Colony diameter in treatment

3. Results and Discussion

Three fungicides saaf, bavistin and tebuconazole were evaluated with three different concentrations *viz.* 200, 400 and 600 ppm by poisoned food technique against four isolates *F. verticillioides* (Fv SC-01, 02, 03 and 04). All the tested fungicides significantly (*P*=0.05) inhibited the mycelial growth and conidial production was not observed at all concentrations from 200, 400 and 600 ppm.

The test fungicides saaf and bavistin completely inhibited of mycelial growth of four isolates *F. verticillioides* (Fv SC-01, 02, 03 and 04) at 200 ppm concentration followed by tebuconazole 97.80, 98.0, 98.33 and 98.55 per cent inhibition of mycelial growth (Table- 1, 2, 3, 4 and Fig-1).

Out of three fungicides tested bavistin and saaf showed maximum per cent inhibition of mycelial growth at 200, 400 and 600 ppm concentration. Third best fungicide tebuconazole showed complete inhibition of the mycelial growth at 400 and 600 ppm concentration, while at 200 ppm concentration it caused 97.80, 98.0, 98.33 and 98.55 per cent inhibition (Fv SC-01, 02, 03 and 04) of all isolates respectively. Tebuconazole was found to cause least inhibition in comparison to other fungicides tested at 200 ppm.

Khokhar *et al*., 2014 [3] evaluated five fungicides agents against *Fusarium verticillioides*, first *in vitro* and then in field to develop effective management strategies for post flowering stalk rot (PFSR) of maize. Systemic fungicides bavistin and tebuconazole (100% and 97.77%) were found most effective in inhibiting the complete mycelial growth of *F. verticillioides in vitro*. Musmade *et al*., 2014 [5] found copper oxychloride to be most effective in retarding growth of *Fusarium verticillioides*, to the extent of more than per centage inhibition over control. It was followed by carbendazim (0.1%), thiram (0.2%) and thiophanate-methyl (0.1%) which showed 86.67%, 79.52% and 71.90% inhibition respectively. Thori *et al*., 2012 tested five fungicides and three biocontrol agents were first evaluated *in vitro* at different concentrations and then on pot grown plants for their integrations against post flowering stalk rot (PFSR) of Maize caused by *Fusarium verticillioides*. Systemic fungicides, bavistin and tebuconazole were found most effective in inhibiting 100% mycelial growth of *F. moniliforme* at 250 ppm.

Table 1: Comparative efficacy of different fungicides on the mycelial growth of *Fusarium verticillioides* SC-01 isolate *in vitro.*

S. No	Concentration (ppm)	Colony diameter (mm)*			Per cent growth inhibition*		
		Saaf	Bavistin	Tebu-conazole	Saaf	Bavistin	Tebu-conazole
1.	200	0.0	0.0	2.0	100.00 (90.00)	100.00 (90.00)	97.80 (81.39)
2.	400	0.0	0.0	0.0	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
3.	600	0.0	0.0	0.0	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
4.	Control	90.0	90.0	90.0	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
		SEm±	CD (P=0.05)		SEm±	CD (P=0.05)	
	Fungicide	0.04	0.121		0.05	0.140	
	Concentration	0.04	0.121		0.05	0.140	
	F × C	0.07	0.210		0.08	0.242	
	C.V. %	4.21%			C.V. %	0.19%	

*Mean of four replications; Figures in parentheses are arcsine √ per cent angular transformed value

Table 2: Comparative efficacy of different fungicides on the mycelial growth of *Fusarium verticillioides* SC-02 isolate *in vitro.*

S. No	Concentration (ppm)	Colony diameter (mm)*			Per cent growth inhibition*		
		Saaf	Bavistin	Tebu-conazole	Saaf	Bavistin	Tebu-conazole
1.	200	0.0	0.0	1.8	100.00 (90.00)	100.00 (90.00)	98.00 (81.84)
2.	400	0.0	0.0	0.0	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
3.	600	0.0	0.0	0.0	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
4.	Control	90.0	90.0	90.0	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
		SEm±	CD (P=0.05)		SEm±	CD (P=0.05)	
	Fungicide	0.04	0.110		0.03	0.104	
	Concentration	0.04	0.110		0.03	0.104	
	F × C	0.06	0.190		0.06	0.180	
	C.V. %	3.85%			C.V. %	0.14%	

*Mean of four replications; Figures in parentheses are arcsine √ per cent angular transformed value

Table 3: Comparative efficacy of different fungicides on the mycelial growth of *Fusarium verticillioides* SC-03 isolate *in vitro.*

S. No	Concentration (ppm)	Colony diameter (mm)*			Per cent growth inhibition*		
		Saaf	Bavistin	Tebu-conazole	Saaf	Bavistin	Tebu-conazole
1.	200	0.0	0.0	1.5	100.00 (90.00)	100.00 (90.00)	98.33 (82.48)

2.	400	0.0	0.0	0.0	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
3.	600	0.0	0.0	0.0	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
4.	Control	90.0	90.0	90.0	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
		SEm±	CD (P=0.05)		SEm±	CD (P=0.05)	
	Fungicide	0.04	0.120		0.038	0.113	
	Concentration	0.04	0.120		0.038	0.113	
	F × C	0.07	0.208		0.067	0.196	
	C.V. %	4.31%			C.V. %	0.15%	

*Mean of four replications; Figures in parentheses are arcsine √ per cent angular transformed value

Table 4: Comparative efficacy of different fungicides on the mycelial growth of *Fusarium verticillioides* SC-04 isolate *in vitro.*

S. No.	Concentration (ppm)	Colony diameter (mm)*			Per cent growth inhibition*		
		Saaf	Bavistin	Tebu-conazole	Saaf	Bavistin	Tebu-conazole
1.	200	0.0	0.0	1.3	100.00 (90.00)	100.00 (90.00)	98.55 (82.94)
2.	400	0.0	0.0	0.0	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
3.	600	0.0	0.0	0.0	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
4.	Control	90.0	90.0	90.0	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
		SEm±	CD (P=0.05)		SEm±	CD (P=0.05)	
	Fungicide	0.044	0.129		0.041	0.120	
	Concentration	0.044	0.129		0.041	0.120	
	F × C	0.070	0.223		0.060	0.208	
	C.V. %	4.71%			C.V. %	0.16%	

*Mean of four replications; Figures in parentheses are arine √ per cent angular transformed value

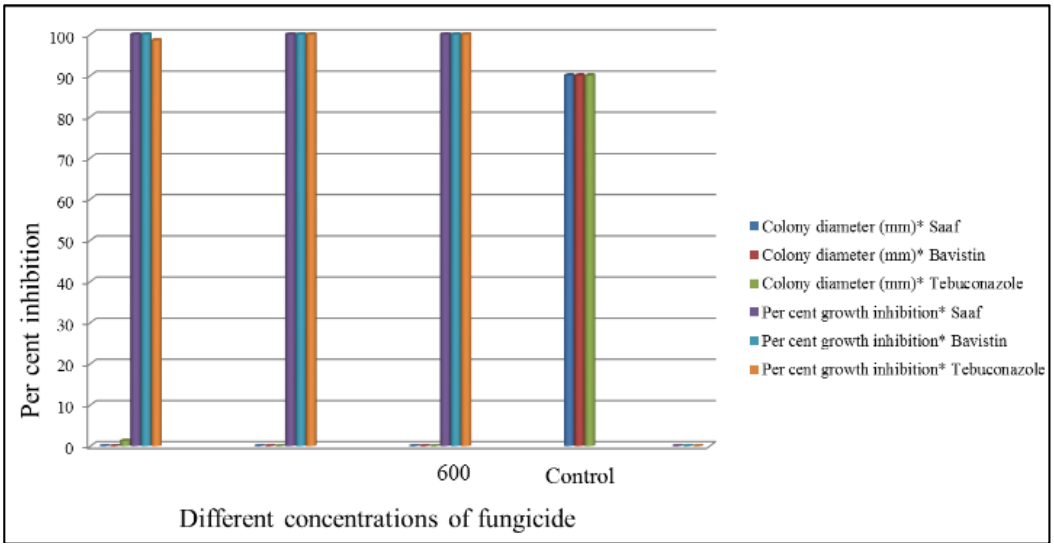
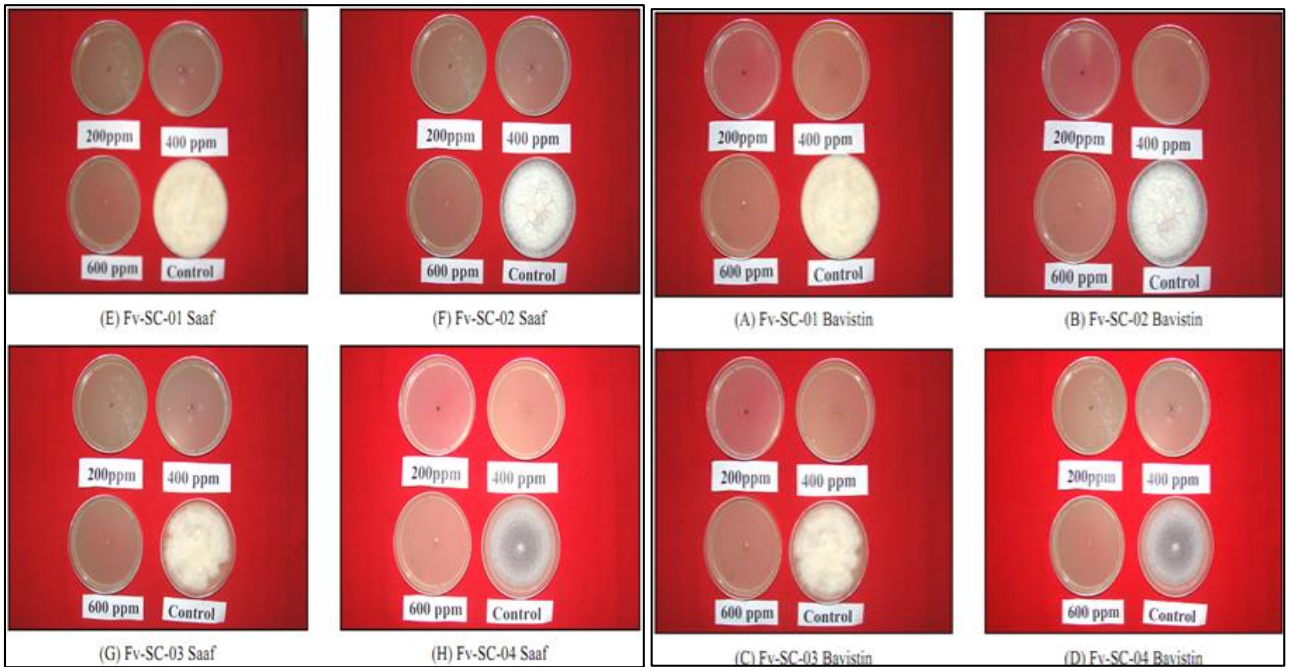


Fig 1: Comparative efficacy of different fungicides on the mycelial growth of *Fusarium verticillioides* SC-04 isolate *in vitro.*



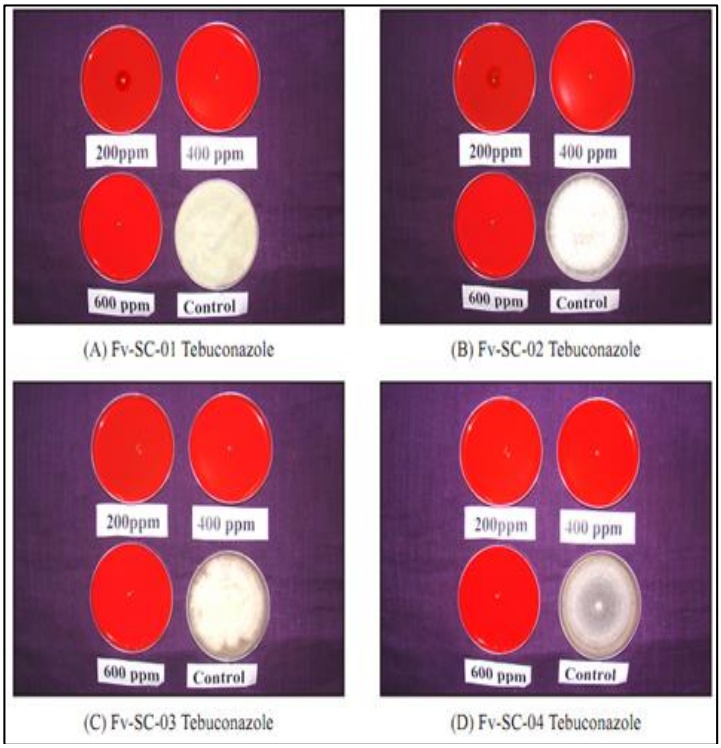


Plate: Inhibition of mycelial growth of *F. verticillioides* isolated by different concentration of fungicide *in vitro* compared to control.

4. Conclusion

To develop effective management strategies for this disease, three systemic fungicides was evaluated against *F. verticillioides* (Fv SC-01 to Fv SC-04) *in vitro* condition. Bavistin and saaf @ 200, 400 and 600 ppm were found most effective in inhibiting the mycelial growth of pathogen.

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