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Evaluation of fungicides and plant extracts against smut of pearl millet caused by *Moesziomyces penicillariae* (Bref.) Vanky

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Abstract
Smut of pearl millet incited by *Moesziomyces penicillariae* (Bref.) Vanky is soil borne disease and is the most destructive and widespread disease of pearl millet in India and other parts of world where it is grown. The experiment was conducted under *in vitro* conditions and two superior fungicides and botanicals were tested under field conditions. Under *in vitro* conditions among fungicides carbendazim and copper oxychloride @ 50 ppm and among plant extracts aloe vera followed by jamun at 20% concentration showed maximum inhibition of pathogen. Under field conditions the fungicides were better over plant extracts and carbendazim performed better as prophylactic spray and showed less smut severity and more grain yield whereas copper oxychloride was better as curative.

Keywords: Pearl millet, smut, fungicides, plant extracts, management

Introduction
Pearl millet (*Pennisetum glaucum* (L.) R. Br.), also known as bajra is the oldest cultivated crop of African and Asian countries. It is an important cereal crop for the population living in drought prone arid and semi arid regions of less developed countries in the world. It has been grown in Africa and the Indian subcontinent since prehistoric times. The center of diversity and suggested area of domestication of this crop is in the Sahel zone of West Africa. As it is a predominately rainfed crop it thrives well in low rainfall and relatively poor soils. Due to its greater adaptability under wide range of agro climatic conditions the crop is grown mostly in the states of Haryana, Rajasthan, Andhra Pradesh, Gujrat, Punjab, Tamil Nadu, New Delhi, Madhya Pradesh and Uttar Pradesh.

Pearl millet is prone to many diseases *viz.*, downy mildew, ergot, blast, rust which cause very high economic losses and smut is one of the economically important disease. Smut caused by *Moesziomyces penicillariae* (Bref.) Vanky is a destructive and widespread disease in the areas where this crop is cultivated. The incitant of pearl millet smut is a facultative saprophyte, belonging to the order Ustilaginales. Smut of pearl millet was first reported by Chevalier (1931) in the early 1930 in Senegal. In India it was first reported by Butler in 1918. Due to commercial cultivation of F1 hybrid the disease resulted into the major outbreak.

Though the work has been done on the management aspect of this disease but identification of promising fungicides is a continuous process for the effective management of the disease. Keeping this in view the present study was undertaken for evaluation of toxicity of fungicides and plant extracts against *M. penicillariae in vitro* and the efficacy of two superior fungicides and plant extracts was checked under field conditions as prophylactic and curative treatment.

Table 1: List of fungicides evaluated along with their chemical, common and trade name.

S. No.	Chemical name	Common name	Trade name
1	Methyl-2- benzimidazole- carbamate	Carbendazim 50% WP	Bavistin
2	Copper(2) chloride hydroxide	Copper oxychloride 50% WP	Blitox
3	1-[[2-(2,4-dichlorophenyl)-4-propyl-1,3-dioxolan-2-yl]methyl]-1,2,4-triazole	Propiconazole 25% EC	Tilt
4	RS)-2-(2,4-dichlorophenyl)-1-(1H-1,2,4-triazol-1-yl)hexan-2-ol	Hexaconazole 5% SC	Hexacare
5	Manganese ethylene bisdithio-carbamate plus zinc	Mancozeb 75% WP	Indofil-45

Table 2: List of plant extracts evaluated along with their botanical name and family.

S. No.	Common name	Botanical name	Family
1.	Safeda	*Eucalyptus*	Myrtaceae
2.	Jamun	*Syzygium cumini*	Myrtaceae
3.	Neem	*Azadirachta indica*	Meliaceae
4.	Aloe	*Aloe barbadensis*	Asphodelaceae
5.	Lantana	*Lantana camara*	Verbenaceae

Materials and methods

Five fungicides *viz.*, mancozeb, carbendazim, propiconazole, hexaconazole and copper oxychloride were evaluated for their toxicity to *M. penicillariae* under *in vitro* conditions at different concentrations *i.e.* 50 ppm, 100 ppm, 200 ppm and 500 ppm using poison food technique. Stock solution of fungicides were prepared by dissolving required quantity of fungicides in 5 ml acetone. For control purpose sterlised distilled water was used. Double strength PDA was amended with the desired concentration of the fungicides and amended PDA from each flask was poured into three sterlised petri plates. After the medium was solidified the plates were inoculated with the sporidial suspension of M. penicillariae taken from ten days old culture. The inoculated petri plates were incubated at 30 ˚C. After one week of incubation, the colony diameter in each plate was measured and per cent inhibition was calculated for different treatments over check.

Similarly five plant extracts namely jamun, aloe vera, lantana, neem and safeda were evaluated at 20 per cent concentration for their toxicity to *M. penicillariae* under *in vitro* conditions. The plant extracts were prepared by crushing 100 g leaves of each plant in 100 ml distilled water using mixer and grinder. The supernatant was filtered through muslin cloth followed by Whatman filter paper No. 1. The filtrate was centrifuged at 5000 rpm for 20 min and clear supernatant obtained was used for the further experiment.

For evaluation of fungicides and plant extracts under field conditions, field trials were conducted at CCSHAU, Hisar during *kharif* 2016. Test host HHB 197 was sown in mid July in the plot size of 5 X 3 meter in randomized block design with three replications. From each replication twenty plants were randomly tagged for pre and post inoculation spray. Two plant extracts *viz.*, Aloe vera @ 20%, jamun @ 20% concentration and two fungicides viz., copper oxychloride @ 0.05% and carbendazim @ 0.05% were evaluated as pre and post inoculation spray for management of pearl millet smut caused by *M. penicillariae*. Observations were taken after 15-20 days and yield data was recorded after complete grain formation. The relative efficiency of fungicides and plant extract(s) was determined on the basis of control.

The detail of chemical name and trade name of the fungicides evaluated is given in Table 1 and the list of plant extracts evaluated against *M. penicillariae* is given in Table 2.

Table 3: Evaluation of fungicides on growth inhibition of *M. penicillariae* under *in vitro* conditions

Treatment	Growth inhibition (%)				Mean
	Concentration (ppm)				
	50	100	200	500	
Mancozeb 75% WP	9.12 (17.28)*	9.41 (17.78)	16.18 (23.70)	32.06 (34.46)	16.69 (23.30)
Hexaconazole 5% SC	49.41 (44.77)	66.18 (54.42)	72.94 (58.63)	88.82 (70.47)	69.34 (57.08)
Propiconazole 25% EC	46.18 (42.82)	61.47 (51.62)	69.41 (56.40)	83.82 (66.26)	69.72 (54.28)
Copperoxychloride 50% WP	100.00 (89.39)	100.00 (89.39)	100.00 (89.39)	100.00 (89.39)	100.00 (89.39)
Carbendazim 50% WP	100.00 (89.39)	100.00 (89.39)	100.00 (89.39)	100.00 (89.39)	100.00 (89.39)
Control	0.00 (0.57)	0.00 (0.57)	0.00 (0.57)	0.00 (0.57)	0.00 (0.57)
Mean	50.79 (56.73)	56.18 (60.52)	59.76 (63.50)	67.45 (69.99)	
	Treatment	Concentration			
SE (m)	0.80	0.72			
C.D. (0.05)	2.29	2.05			

* Values in parentheses are angular transformed values

Table 4: Evaluation of plant extract(s) on growth inhibition of *M. penicillariae* under *in vitro* conditions

Leaf extract (20% concentration)	Growth inhibition (%)
Lantana	33.13 (35.12)
Neem	24.42 (29.59)
Jamun	38.95 (38.60)
Eucalyptus	4.65 (12.20)
Aloe vera	100 (89.39)
Control	0 (0.57)
SE(m)	0.696
C.D. (0.05)	2.084

- Average of four replications

* Values in parentheses are angular transformed values

Table 5: Evaluation of plant extract(s) and fungicides as prophylactic and curative treatment for management of *M. penicillariae in vivo*

Treatment		Smut severity (%)	Disease control (%)	Yield (Kg/ha)
T_1	Aloe vera @ 20% concentration as PIS	2.00 (6.22)	97.50	2511
T_2	Jamun @ 20% concentration as PIS	3.67 (10.52)	95.42	2355
T_3	Copper oxy chloride @ 0.05% as PIS	3.00 (9.72)	96.25	2389
T_4	Carbendazim @ 0.05% as PIS	1.67 (7.33)	97.92	2544
T_5	Aloe vera @ 20% concentration as PoIS	16.67 (23.84)	79.17	1900
T_6	Jamun @ 20% concentration as PoIS	20.00 (26.55)	75.00	1711
T_7	Copper oxy chloride @ 0.05% as PoIS	13.33 (21.13)	83.33	1955
T_8	Carbendazim @ 0.05% as PoIS	16.67 (23.84)	79.17	1933

T_9	Control with sterlized water as PoIS	66.67 (54.98)	16.67	533
T_{10}	Control without water	80.00 (63.83)	0.00	400
SE(m)		2.99		121.29
C.D. at 5%		8.98		363.18

* Values in parentheses are angular transformed values

a) PIS- Pre inoculation spray ; b) PoIS- post inoculation spray

Results and Discussion

Different fungicides and leaf extracts were evaluated for management of pearl millet smut. *In vitro* growth inhibition test revealed that the fungicides and botanical extracts varied considerably in their toxicity to *M. penicillariae.* Carbendazim and copper oxychloride at 50 ppm were found to be significantly effective against *M. penicillariae* followed by propiconazole and hexaconazole whereas mancozeb was the least effective fungicide, however it exhibited significant difference in comparison to control(Table 3). These results support the findings of Kumar and Nath (1991) [3] for managing long smut of sorghum caused by *Tolyposporium ehrenbergii* but in contrary to the findings of Meena *et al*. (2010) [6] who reported propiconazole and hexaconazole as more effective fungicides as compared to carbendazim.

All the plant extracts were found significantly superior in inhibiting the growth of fungus in comparison to the control. Highest growth inhibition was found in *aloe vera* extract followed by jamun extract (Table 4) In the present study, *Eucalyptus* leaf extract @ 20% was found to be least effective which differs with the findings of Rajput (2000) [8] who observed that *Eucalyptus* leaf extract @ 10% was found best among *Parthenium*, *Calotropis* and neem leaf extracts against *Tolyposporium penicillariae* under *in vitro* condition. Choursia (2007) [2] tested 11 botanicals in boil form in two concentrations *i.e.* 10 & 20% against *T. penicillariae* and reported that *Eucalyptus* extract @ 20% showed maximum control of mycelial growth as compared to control.

In the pre inoculation as well as post inoculation foliar sprays of carbendazim (0.05%), copper oxy chloride (0.05%), *aloe vera* extract (20%) and jamun extract (20%) were carried out for the management of pearl smut under *in vivo* condition. The spray of fungicide as well as plant extract as pre inoculation treatment was better than the post inoculation treatment. The average yield obtained was also more in pre inoculation treatment in comparison to the post inoculation treatment. Among, prophylactic spray of fungicides, carbendazim was found to be more effective than copper oxychloride but in post inoculation spray disease severity was less in copper oxychloride treatment. Amongst different plant extracts sprayed less smut severity and more yield was found in pre inoculation spray with *aloe vera* and post inoculation spray with jamun extract. However the present findings were contradictory to the findings of Rajput (2000) [8] according to which eucalyptus leaf extract @ 10% was better than the *Calotropis*, *Parthenium* and neem leaf extract in managing the smut of pearl millet. Phookan (1987) [7], reported carboxin as effective fungicide followed by captofol and carbendazim for managing the smut under field conditions. Kumar (2011) [4] reported that four sprays of captafol (3g l^{-1}) effectively managed the disease in the field. Meena *et al.*, (2012) [5] reported that hexaconazole and propiconazole were superior over carboxin for management of pearl millet smut under field conditions.

Conclusion

The major limitations to chemical control of smut in pearl millet are low monetary value of the crop, and scarcity of resources available to pearl millet growing farmers. For effective and economic control of the pathogen a combination of fungicide and plant extract as spray treatment for managing the smut is the requirement of current era.

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