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Development of integrated spray schedule for the management of Curvularia leaf spot of maize

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Abstract: Curvularia leaf spot (CLS) caused by *Curvularia lunata* (Wakk.) Boedijn, is a major disease problem in maize. Presently moderate to high severity has been recorded in Karnataka. An attempt was made to evaluate fungicides and commercially available botanicals to test under *in vitro* by using poison food technique and indigenous technology knowledge (ITK'S) by "cavity slide" method. Further based on the results of *in vitro* studies, a spray schedule was developed involving cost effective fungicides, botanicals and ITK'S. Hexaconazole, propiconazole and triadimefon among systemic fungicides at 0.025, 0.05 and 0.1 per cent, carbendazim + mancozeb and propineb among non systemic fungicides at 0.2 and 0.3 per cent, wanis among commercially available botanicals at 0.2 and 0.3 per cent concentration inhibited maximum mycelial growth of *C. lunata* and panchagavya among the ITK'S at 20 and 30 per cent concentration recorded maximum inhibition of spore germination of *C.lunata*. Among different spray schedules evaluated under field condition, hexaconazole @ 0.1 % - hexaconazole @ 0.1% spray schedule recorded least Curvularia leaf spot severity (42.35%), highest grain yield (79.58 q/ha) , 100 grain weight (41.33g) and stover yield (8.02t/ha) with highest benefit: cost of 3.81.

Key words: Botanicals, Indigenous technology knowledge, Maize, *Curvularia lunata*

Introduction

Maize (*Zea mays* L.) is one of the most important cereal crops in the world and ranks third next to wheat and rice. It is grown throughout the world under a wide range of climatic conditions. Since pre-Hispanic time, it has been the basic food for majority of the people in Mexico, Central America and Latin America. Maize was introduced to India from America at the beginning of 17th century. In addition to staple food for human being and quality feed for animals, it serves as a basic raw material as an ingredient to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries *etc.* In the last one decade, it has registered the highest growth rate among all food grains including wheat and rice because of newly emerging food habits as well as enhanced industrial requirements.

In India, it is cultivated both as food and fodder crop. It has got immense potential and hence called as 'Miracle crop' and also called as 'Queen of cereals'. In the future, maize demand is expected to increase, mainly because it is used by larger population as human food and due to its increased consumption as feed in poultry for animal protein. Besides multiple uses contribute to diet diversification and improved nutrition in human beings through exploitation of quality protein maize (Singhal, 2003). Every part of the maize plant has economical value: the grain, leaves, stalks, tassel and cob can all be used to produce a large variety of food and non food products (Akobundu and Agyakwa, 1987). Globally maize occupies an area of 174.2 m ha with the production of 852 m t and productivity accounts for 4890 kg ha^{-1}. In India, the maize is cultivated in occupies an area of 9.42 m ha with the production of 22.26 m t and average productivity of 2583 kg ha^{-1}. In Karnataka maize occupies an area of 1.38 m ha, with the production of 4.00 m t and average productivity is 2883 kg ha^{-1} (Anon., 2014).

Material and Methods

***In vitro* evaluation of fungicides, commercially available botanicals and indigenous technology knowledge against *Curvularia lunata* :** The *in vitro* studies were carried out in the Department of Plant Pathology, College of Agriculture, Vijayapur, University of Agricultural Sciences, Dharwad, Karnataka. Six systemic (carbendazim, difenconazole, hexaconazole, propiconazole, thiophanate methyl and triadimefon), four non systemic (chlorothalonil, mancozeb, carbendazim + mancozeb and propineb) fungicides and six commercially available botanicals *viz.,* neem gold(Azadirachtin 0.03%EC), neem oil(Azadirachtin), nimbicidine (Azadirachtin 0.03% EC), sainik(organic systemic fungicide), soldier (*Aegle marbelos* (20%), *Ricinus communis* (20%), *Hygrophila spinosa* (20%), *Laminaria spp*. (20%) and

Lantana camera (20%)) and wanis (organic product (20%EC W/W) were used. Systemic fungicides at 0.025, 0.05 and 0.1 per cent, non systemic fungicides at 0.1, 0.2 and 0.3 per cent and commercially available botanicals at 0.25, 0.5, 0.75 and 1.0 per cent, were tested by following poison food technique (Zentmeyer, 1955) for their efficacy against *C. lunata* for inhibition of radial growth on the potato dextrose agar (PDA) medium. Three replications were maintained for each treatment. The fungus grown on the PDA agar medium without any fungicides / botanicals served as control. The per cent inhibition of the mycelial growth of the fungus was determined by using the following formula (Vincent, 1947).

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

Where, I= Per cent inhibition of radial growth of the fungus, C= Radial growth of the fungus in control, T= Radial growth of the fungus in treatment (fungicide/ botanicals).

Five indigenous technology knowledge *viz.,* cow urine, cow milk, butter milk, panchagavya and vermiwash were evaluated *in vitro* on inhibition of spore germination of *C. lunata* by following "cavity slide" method at 5, 10, 20 and 30% concentrations. Required concentrations of each product were prepared in distilled water for each treatment and three replications were maintained for each treatment. Control treatment was maintained with distilled water. One hundred spores were observed for germination after six hours of incubation in moist chamber. Per cent spore germination was calculated by using following formula.

$$\text{Per cent spore germination (PG)} = \frac{A}{B} \times 100$$

Where, A = No. of spores germinated, B = No. of spores observed. The percent inhibition of spore germination was calculated by the following formula given by Vincent (1947).

$$C = \frac{C - T}{C} \times 100$$

Where, I= Per cent inhibition of spore germination, C = Spore germination percentage in control, T= Spore germination percentage in treatment. Further angular transformations were made for data and analyzed stastically.

Treatments	Spray schedule	
	1st Spray	2nd Spray
T1	PBP	PBP
T2	ITK	ITK
T3	F1	F1
T4	F2	F2
T5	F1	PBP
T6	F2	PBP
T7	F1	ITK
T8	F2	ITK
T9	Unsprayed control	

PBP: Plant based product, ITK: Indigenous Technology Knowledge and F: Fungicide

Based on the results obtained by *in vitro* evaluation, an integrated spray schedule as mentioned below was prepared by involving effective and economically viable fungicides, botanical and ITK and tested under field condition. Field experiment was laid out in a randomized block design with three replications at the Agricultural Research Station, Arabhavi during *kharif* 2014 under irrigated condition using susceptible maize genotype, CP 818.

Crop was raised as per recommended package of practice. Two sprays were given in each treatment at fifteen days interval starting from on the onset of disease. Observations on Curvularia leaf spot severity was taken at physiological maturity by following 0 to 9 scale of Mayee and Datar (1986). Grain yield per plot and 100 grain weight were noted down after the harvest of the crop

Results and discussion

In vitro* evaluation of fungicides, commercially available botanicals and indigenous technology knowledge against *Curvularia lunata: In the present investigation six systemic and four non systemic fungicides, six commercially available botanicals were tested *in vitro* on inhibition of mycelial growth by following poison food technique and five indigenous technology knowledge (ITK'S) were evaluated *in vitro* against spore germination of *C.lunata* by cavity slide method as described under material and methods.

Among the six systemic fungicides, hexaconazole, propiconazole and triadimefon recorded significantly higher inhibition of mycecial growth at 0.025, 0.05 and 0.1 per cent concentrations (Table 1). Difenconazole was found next best and it is on par with hexaconazole, propiconazole and triadimefon at 0.025, 0.05 and 0.1 per cent concentrations. Thiophanate methyl and carbendazim were less effective compared to, hexaconazole, propiconazole and triadimefon at all the concentrations tested. Among non systemic fungicides maximum inhibition was recorded by carbendazim + mancozeb and propineb at 0.2 and 0.3 per cent concentrations (Table 1). Effectiveness of triazole fungicides against Curvularia leaf spot in different crops has been documented by many workers. Sumangala *et al.* (2008) reported maximum inhibition of mycelial growth of *C. lunata* in difenoconazole (98.80%) and propiconazole (98.10%) at 0.1 per cent concentration. Among the three non-systemic fungicides tested, mancozeb (98.80%) was found most effective followed by chlorothalonil (63.67%) at 0.2 per cent concentration.

All the six botanicals reduced mycelial growth inhibition of *C.lunata* at all the concentrations tested. Wanis recorded maximum inhibition compared to the other botanicals. Next best botanicals were nimbicidine and neem gold and least inhibition was with soldier at all the concentrations. Bisht *et al.* (2013) observed significant difference among the different plant extracts evaluated *in vitro* against inhibition of mycelial growth of *C. lunata.* Amongst the plant extracts, lantana was highly effective @ 15 per cent (86.76% inhibition) and 20 per cent (89.49% inhibition) followed by morphankhi @ 5 per cent (83.53% inhibition) and 10 per cent (85.88% inhibition), respectively. The mycelial growth inhibition rate was increased with increase in the plant extracts concentrations.

Use of indigenous technology knowledge in the management of plant diseases is an age old practice. Use of animal

Table-1: *In vitro* evaluation of different systemic and non systemic fungicides on mycelia growth of *C. lunata*

Systemic fungicides	% inhibition of mycelial growth in different concentration			
	0.025%	0.05%	0.1%	Mean
Carbendazim	20.28(26.75)*	28.33(32.16)	29.72(33.03)	26.11(30.73)
Difenconazole	91.67(73.33)	92.36(73.95)	100.00(90.00)	94.67(76.66)
Hexaconazole	100.00 (90.00)	100.00(90.00)	100.00(90.00)	100.00(90.00)
Propiconazole	100.00(90.00)	100.00(90.00)	100.00(90.00)	100.00(90.00)
Thiophanate methyl	26.67(31.09)	31.67(34.25)	47.21(43.40)	35.18(36.38)
Triadimefon	100.00(90.00)	100.00(90.00)	100.00(90.00)	100.00(90.00)
Mean	56.43(48.69)	75.39(60.26)	79.48(63.06)	75.19(57.54)
	Fungicides (F)	Concentrations (C)	Interaction (F×C)	
S.Em±	1.25	0.88	2.17	
C.D.at 1%	4.74	3.35	8.21	
Non systemic fungicides	**% inhibition of mycelial growth in different concentration**			
	0.1 %	**0.2%**	**0.3%**	**Mean**
Chlorothalonil	14.81(22.63)*	28.15(32.04)	70.56(57.14)	37.84(37.96)
Mancozeb	74.26(59.51)	84.44(66.77)	90.74(72.28)	83.15(65.76)
Propineb	73.89(59.27)	100.00(90.00)	100.00(90.00)	91.30(72.84)
Carbendazim 12% WP +Mancozeb 63% WP	75.93(60.62)	100.00(90.00)	100.00(90.00)	91.98(73.55)
Mean	59.72(47.48)	78.15(69.59)	90.33(71.88)	76.07(60.71)
	Fungicides (F)	Concentrations (C)	Interaction (F×C)	
S.Em±	0.25	0.22	0.44	
C.D.at 1%	0.96	0.82	1.65	

* Arc sine transformed values

Table-2: *In vitro* evaluation of commercially available botanicals on mycelial growth of *C. lunata*

Botanicals	% inhibition of mycelial growth in different concentration			
	0.25%	0.5%	0.1%	Mean
Neem gold	59.25(50.33)*	65.64(54.74)	73.83(60.55)	66.24(54.48)
Neem oil	22.78(28.51)	29.44(32.86)	34.44(35.93)	28.88(32.51)
Nimbicidine	60.56(51.10)	66.67(54.74)	75.83(60.56)	67.69(55.35)
Sainik	23.78(28.41)	38.89(38.58)	50.83(45.48)	37.50(37.76)
Soldier	2.78(09.60)	6.39(14.64)	32.21(34.58)	13.79(21.80)
Wanis	87.50(69.30)	100.00(90.00)	100.00(90.00)	95.83(78.22)
Mean	42.61(40.75)	51.17(45.67)	61.19(51.47)	
	Botanicals (B)	Concentrations (C)	Interaction (F×C)	
S.Em±	1.98	1.40	3.43	
C.D.at 1%	7.48	5.28	N S	

products such as cow urine, cow milk and butter milk in the plant disease management has been described in Vedas, Arthashstra, Agnipurana and Surpalas (Nene, 2003 and Sadhale, 1996). In the present study, five ITK'S were tested against spore germination of *C.lunata* and data are presented in Table 3. All the five ITK's showed inhibition of spore germination of *C.lunata* at all the concentrations tested. Irrespective of ITK concentration, panchagavya (87.88%) was found best in inhibition of spore germination followed by vermiwash (70.80%). These results are in agreement with Sumangala and Patil, (2007) who studied the antifungal activity of panchagavya against *C. lunata* in rice, which found to be the dominant pathogen in causing grain discolouration. Panchagavya resulted in 86.30 per cent inhibition of mycelial growth and 95.90 per cent of spore germination of *C. lunata*. Seed treatment with panchagavya further enhanced the seed germination with 90.70 per cent and vigor index of 1036.

Effect of spray schedules on severity of Curvularia leaf spot of maize : Based on the *in vitro* evaluation results, the spray schedule involving effective and economically viable systemic fungicide (hexaconazole), non systemic fungicide (carbendazim + mancozeb), commercially available botanical (wanis) and indigenous technology knowledge (panchagavya) were evaluated by conducting field experiment in randomized block design with three replications during *kharif* 2014 and the results are presented in Table 4.

Among the eight spray schedule, hexaconazole @0.1%- hexaconazole @ 0.1% (T_5) recorded the least Curvularia leaf spot severity (42.35 %), highest grain yield (79.58 q/ha), 100 grain weight (41.33g), stover yield (8.02 t/ha) with highest benefit :cost of 3.81. However, in terms of grain yield, 100 grain weight, stover yield and B:C, hexaconazole @0.1%- wanis @ 0.5% (T_5) spray schedule was found next best. Highest Curvularia leaf spot severity (75.91 %) with lowest grain yield (52.08 q/ha), 100 grain weight (35.00g), stover yield (6.30 q/ha) and B:C (2.18) was recorded in unsprayed control. These results are in agreement with Hurali (2008) who confirmed least disease severity of 26.07 per cent in hexaconazole@0.1% - hexaconazole@0.1% spray schedule followed by cristol 56SL@ 1.0% – hexaconazole@0.1% – cristol 56SL@1.0% (27.71 %) spray schedule. Whereas, neem oil @1.0% – hexaconazole @0.1% – neem oil@ 1.0% spray schedule recorded maximum (23.16 q ha^{-1}) seed yield followed by cow milk@10% – hexaconazole@0.1% – cow milk@10% (22.66 q ha^{-1}) spray schedule against soybean rust. The present findings are also in agreement with Patil (2007) who reported that among the seven commercially available plant based products tested *viz*., neem oil, margotricure, nimbicidine and neem gold at 0.5 per cent and wanis at 1.0 per cent, sprayed thrice at an interval of 10 days starting from the onset of disease were found promising in reducing the soybean rust severity with significant increase in seed yield and 100 seed weight. Among the botanicals highest B: C (2.74) was recorded in neem oil followed by margotricure (1.12) and nimbicidine (0.96). Patil and Basavaraj (2014) reported that spray schedule of cow milk @ 10%-hexaconazole @ 0.1%-cow milk @ 10%, cristol 56SL @ 1.0%- hexaconazole @ 0.1%- cristol56SL @ 1.0% and neem oil 1.0%- hexaconazole @ 0.1%- neem oil 1.0% at 15 days of

Table-3: *In vitro* evaluation of ITK'S on conidial germination of *C. lunata*

ITK'S	Percent inhibition of conidial germination at different concentration				
	5%	10%	20%	30%	Mean
Butter milk	7.18(15.54)*	8.53(16.98)	8.56(17.01)	9.77(18.21)	8.95(17.41)
Cow urine	1.04(05.85)	3.49(10.77)	3.90(11.39)	4.44(12.16)	3.94(11.45)
Cow milk	9.25(17.71)	11.98(20.25)	13.46(21.52)	15.85(23.46)	13.76(21.78)
Panchagavya	85.78(67.85)	86.78(68.68)	87.78(69.54)	89.09(70.71)	87.88(69.63)
Vermiwash	62.52(52.25)	67.19(55.06)	71.29(57.60)	73.91(59.28)	70.80(57.29)
Mean	33.15(32.16)	35.59(36.63)	37 (37.46)	38.61(38.61)	37.07(37.51)
		ITK'S (I)	Concentrations (C)	Interaction (I×C)	
S.Em±		1.52	1.36	3.04	
C.D.at 1%		5.66	5.06	NS	

* Arc sine transformed values

Table-4: Effect of spray schedules on severity of Curvularia leaf spot of maize during *kharif* 2014

Tr.No.	Spray schedule		Percent Disease Index(PDI)	Grain yield (q/ha)	100 grain weight(g)	Stover yield (t/ha)	B:C
	I Spray	II Spray					
T_1	Wanis @ 0.5%	Wanis @ 0.5%	62.54(52.26)*	57.47	37.33	7.00	2.40
T_2	Panchagavya @ 10%	Panchagavya @ 10%	68.66(55.96)	60.42	36.40	6.55	2.43
T_3	Hexaconazole @ 0.1%	Hexaconazole @ 0.1%	42.35(40.60)	79.58	41.33	8.02	3.81
T_4	Carbendazim + mancozeb @ 0.2%	Carbendazim+mancozeb @ 0.2%	56.02(48.46)	64.90	38.66	7.08	2.71
T_5	Hexaconazole@0.1%	Wanis @ 0.5%	53.15(46.80)	66.01	40.00	7.92	2.81
T_6	Carbendazim + mancozeb @ 0.2%	Wanis @ 0.5%	55.33(48.06)	67.08	39.66	7.38	2.81
T_7	Hexaconazole @ 0.1%	Panchagavya @ 10%	61.40(51.59)	61.67	38.00	7.05	2.69
T_8	Carbendazim + mancozeb @ 0.2%	Panchagavya @10%	65.72(54.16)	59.97	37.17	6.67	2.42
T_9			75.91(60.61)	52.08	35.00	6.30	2.18
S.Em±			3.03	1.22	1.18	0.215	
C.D. at 5%				9.11	3.65	3.54	0.644

* Arc sine transformed values. Cost of grain Rs.1240/q, cost of stover Rs.660/t , cost of fungicide/plant based products in Rs/.Kg or l, hexaconazole(580), carbendazim + mancozeb(600), wanis(450) and panchagavya (Rs.1500/ha). Quantity of spray solution used for two sprays per hectare Rs – 1250 l. Cost of cultivation Rs.-20,000/ha

interval was found best in reducing rust intensity and increasing grain yields of soybean.

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