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SCREENING OF CHILLI GENOTYPES AGAINST *COLLETOTRICHUM CAPSICI* CAUSING ANTHRACNOSE AND ITS MANAGEMENT

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ABSTRACT
Twenty Chilli genotypes were tested, during *Kharif* 2012 and 2013 for their reaction to *Colletotrichum capsici* under field conditions. Out of twenty genotypes evaluated, two genotypes *viz*., Arka Meghana and Byadagi Kaddi showed resistant reaction. Whereas, four genotypes *viz*., Musalwadi, Ujwala, Arka Lohit and Sankeshwara showed moderately resistant reaction and rest of them showed moderately susceptible and susceptible reaction. Among 10 fungicides, 10 botanicals and 7 bio agents were evaluated in *In vitro* condition against *Colletotrichum capsici*, 0.1%Propiconazole-25 EC, 0.1%Tebuconazole-25EC, *Azadirachta indica* (15%) and *Trichoderma harzianum* recorded the maximum inhibition of mycelial growth of *Colletotrichum capsici*. The field evaluation of different fungicides and botanical during *Kharif* 2013 indicated that 0.1%Propiconazole-25 EC was recorded minimum PDI of 21.50 and dry pod yield of 16.44q/ha. 0.1%Tebuconazole-25EC,0.2%Mancozeb-75WP, 0.1%Azoxystrobin-23EC,0.3% Copper oxy chloride- 50WP and 0.2% Captan-50 WP were next best treatments found effective in reducing the disease intensity by recording a PDI of 22.67,23.76,24.66,26.10 and 27.48 and dry pod yield of 15.36q/ha,16.38q/ha,14.28q/ha, 12.70q/ha and 13.07q/ha respectively. Again during *Kharif*-2014, among fungicides 0.1%Propiconazole-25 EC was significantly effective in reducing the disease intensity by recording a PDI of 20.79 and yield of 16.13q/ha and similar trend was observed for other treatments also

INTRODUCTION

Chilli (*Capsicum annuum* L.) is an important spice cum vegetable crop grown under both tropical and subtropical conditions. India is the largest grower, consumer and exporter of chilli, currently exporting to over 90 countries around the world. Chilli cultivation is mostly concentrated in the southern states like, Andhra Pradesh, Karnataka, Maharashtra, Orissa and Tamil Nadu occupying nearly 75 per cent of the total area under this crop in India. It is a good source of vitamin A (292 I.U per 100 g), vitamin C (111mg per 100 g) and thiamine (0.19 mg per 100 g).It is mainly cultivated for three constituents of fruits *viz*., capsaicin, capsanthin and oleoresin. Pungency, one of the important quality attributes of *Capsicum species* is due to the presence of alkaloid 'capsaicin' in the fruit. Its production suffers from many diseases caused by fungi, bacteria, viruses, nematodes and abiotic stresses (Choudhary *et al.,* 2013). Among all diseases, anthracnose caused by *Colletotrichum capsici* (Sydow) Butler and Bisby is a major problem in India and one of the more significant economic constraints to chilli production worldwide, especially in tropical and subtropical regions (Than *et al.,* 2008). It affects the crop during the early stage and continues till harvest and causes necrosis of the leaves, tender branches and rotting of the ripe fruits. Badly infected fruits may lose their normal red colour and turn straw colour or in some cases, pale white. This disease causes both pre- and post-harvest fruit decay. In earlier studies, Gurudatt Hegde and Anahosur (2001), Ruth Beulah Rani (2002), Malathi (2004), Pugalendhi *et al*.(2010) were reported the screening of some genotypes to locate the resistant types. In the present studies, an attempt has been made to screen Chilli genotypes against anthracnose disease and its management. Spraying of broad spectrum fungicides has been recommended for management of disease. Control achieved by these chemicals is inadequate. Therefore, it is thought worthwhile to test the efficacy of more promising chemicals like Propineb-50WP, Propiconazole-25 EC, Azoxystrobin-23EC, Tebuconazole-25EC,Myclobutanil-10WP against fungus. Not much light has been shed on biological control, botanicals which are effective against *Colletotrichum capsici*. Hence, an attempt has been made to test commonly available botanicals and bio agents against the pathogen.

MATERIALS AND METHODS

Screening of chilli genotypes

An experiment was conducted at College of Horticulture, Bidar, Karnataka during *Kharif* 2012 and 2013 in Randomized Complete Block Design with twenty genotypes *viz*., Byadagi Kaddi, Byadagi Dabbi, Kollegala, Gauribidanur, Sankeshwara, Chincholli, Khadarolli, Musalwadi, Bhagyalakshmi, Punjab Lal, Parbhani Tejas, GPC-82, GPC-80, Jawahar-218, Ujwala, Pant C-1,Pusa Jwala, Hisar Shakti, Arka Lohit and Arka Meghana four week seedlings were planted at a spacing of 60 cm X 30 cm (row to row X plant to plant) in a plot size of 3.6

m X 2.4 m and all the recommended agronomic practices were followed to raise a good crop except fungicidal spray to avoid the killing of fungal pathogen (Anonymous,2013). As there was heavy incidence of anthracnose during both the years, the genotypes were scored for the disease incidence under natural field conditions without artificial inoculation. The disease score was recorded on ten randomly selected plants from each plot per treatment per replication at fortnightly intervals by using 0 to 9 point rating scale (Mayee and Datar, 1986).

Percent Disease Index (PDI) was calculated by using the following formula proposed by Wheeler (1969) as follows.

$$\text{Percent Disease Index(PDI)} = \left(\frac{\text{Sum of all individual ratings} \times 100}{\text{Number of plants examined} \times \text{maximum disease grade}} \right)$$

In vitro evaluation of fungicides

Ten fungicides with different modes of action at recommended dose were evaluated in the laboratory for their efficacy against *Colletotrichum capsici* by the poisoned food technique (Nene and Thapliyal, 1979). Each treatment was replicated 3 times. The molten sterilized PDA was used as nutrient medium and required quantity of each fungicide was added separately so as to get a required concentration of that fungicide. The fungicides were thoroughly mixed by stirring and about 15 ml poisoned medium was poured to each of the 90mm petri dishes and allowed for solidification. The actively growing periphery of 9 day old culture of *Colletotrichum capsici* was carefully cut by using a gel cutter and transferred aseptically to centre of each petri dish containing the poisoned solid medium. Suitable control was maintained by growing the cultures on PDA without the fungicides. The plates were incubated at 27 ± 1ºC for 9 days and the colony diameter was recorded 9 days after growth(Table-2). The percent inhibition of mycelial growth over control was calculated using the formula of Vincent (1947)

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

I = per cent inhibition of mycelial growth

C = radial growth of fungus in control

T = radial growth of fungus in treatment.

In vitro evaluation of botanicals

Healthy plants were selected from which the fresh leaves and other parts were obtained and thoroughly washed with tap water then air dried. Aqueous plant extract was prepared by grinding 100g leaves/other parts with 100ml distilled water (w/v) using a blender and filtrate was collected by passing through double layered muslin cloth. The supernatant was taken as standard plant extract solution (100%). All the extracts obtained were passed through filter paper used for assay. The poisoned food technique (Nene and Thapliyal, 1979) was followed to evaluate the efficacy of botanicals in laboratory against *Colletotrichum capsici* at 15% concentration (Table-3).Each treatment was replicated 3 times. The method followed for conducting the experiment was same as that used for fungicide evaluation.

In vitro evaluation of bio-agents

Dual culture technique (Dennis and Webster, 1971) was followed to study interaction of seven antagonists in the laboratory. Poured 20ml of PDA into 90mm petri dishes and allowed for solidification. Discs measuring 5 mm of *Colletotrichum capsici* was taken from 9 day old culture and was placed at one end of the petri dish then respective antagonistic organisms were inoculated at the opposite side(Table-4). A control was maintained by inoculating only *Colletotrichum capsici* at one end in case of fungal antagonistic. In case of bacterial antagonistic *Colletotrichum capsici* was placed at both ends of petri plates and bacterial culture was inoculated at centre of the petri plate, control was maintained by inoculating *Colletotrichum capsici* at the both the ends of the petri plates. Each treatment was replicated three times and incubated for 6 days at 27 ± 1ºC. The activity of antagonistic organisms were recorded by measuring the colony diameter of *Colletotrichum capsici* in each treatment and compared with control.

Management, *Colletotrichum capsici*

The field experiment was laid out in RCBD with 10 treatments and 3 replications during *Kharif* 2013 and 2014 at College of Horticulture, Bidar, Karnataka. Healthy Byadagi Dabbi four week seedlings were planted in the field with 60cm X 30cm (row to row X plant to plant) spacing in plot size of 3.6 m X 2.4 m. All other cultural practices and pest control practices were followed as recommended in package of practices (Anonymous, 2013). The first spraying was carried out as soon as first symptom of disease was noticed in the field. Four sequential sprays of fungicides and botanical were taken at an interval of 15 days (Table-5 and 6). Disease severity was recorded on ten randomly selected plants in each plot per treatment per replication, just one day before each spraying and fifteen days after last spraying. Observations on severity of disease on foliage was recorded by using 0 to 9 point scale and PDI was worked out. Dry pod yield in each plot was recorded and computed to hectare basis, the percent increase over control was computed as follows.

$$\text{Yield increase over control (\%)} = \frac{\text{Yield in treatment - Yield in control} \times 100}{\text{Yield in control}}$$

RESULTS AND DISCUSSION

Screening of Chilli Genotypes

All the screened genotypes were categorized for their reaction on the basis of PDI values. Those with 1- 10 PDI value were considered as resistant, while those with 11-25 PDI as moderately resistant, 26-50 PDI as moderately susceptible, 51-75 PDI as susceptible and more than75 PDI as highly susceptible (Gurudatt Hegde and Anahosur,2001). Observations indicated that out of twenty genotypes evaluated, two genotypes *viz*., Arka Meghana and Byadagi Kaddi showed resistant reaction. Whereas, four genotypes *viz*., Musalwadi, Ujwala, Arka Lohit and Sankeshwara showed moderately resistant reaction and rest of them showed moderately susceptible and susceptible reaction against anthracnose (Table1). At the time of harvest, dry pod yield was recorded and computed to hectare basis. No relationship between disease severity and dry pod yield was observed, it might be due to genetic potential of genotypes. Gurudatt Hegde and Anahosur (2001) reported Byadagi Kaddi genotype as

Table1: Screening of Chilli genotypes against *Colletotrichum capsici* under field conditions.

Kharif , 2012 Chilli Genotypes	Mean Percent Disease Index	Reaction	Dry Pod Yield (q/ha)	*Kharif*, 2013 Chilli Genotypes	Mean Percent Disease Index	Reaction	Dry Pod Yield (q/ha)
Byadagi Kaddi	9.92^{l}	R	7.17^{g}	Byadagi Kaddi	9.77^{l}	R	8.14^{g}
Byadagi Dabbi	48.60^{c}	MS	11.06^{e}	Byadagi Dabbi	48.20^{c}	MS	11.56^{e}
Kollegala	28.19^{h}	MS	9.45^{f}	Kollegala	31.31^{h}	MS	8.95^{g}
Gauribidanur	33.03^{g}	MS	12.44^{cd}	Gauribidanur	33.98^{fg}	MS	12.97^{de}
Sankeshwara	24.74^{i}	MR	8.12^{g}	Sankeshwara	24.60^{i}	MR	8.90^{g}
Chincholli	31.35^{g}	MS	10.84^{e}	Chincholli	33.28^{g}	MS	10.74^{f}
Khadarolli	32.58^{g}	MS	11.45^{d}	Khadarolli	34.20^{fg}	MS	12.34^{e}
Musalwadi	19.24^{k}	MR	10.68^{e}	Musalwadi	21.04^{k}	MR	10.71^{f}
Bhagyalakshmi	38.61^{e}	MS	12.12^{d}	Bhagyalakshmi	37.50^{e}	MS	14.66^{c}
Punjab Lal	40.28^{de}	MS	12.65^{c}	Punjab Lal	40.30^{d}	MS	11.80^{e}
Parbhani Tejas	55.30^{b}	S	13.08^{c}	Parbhani Tejas	54.21^{b}	S	13.29^{d}
GPC-82	41.66^{d}	MS	11.63^{d}	GPC-82	40.23^{d}	MS	11.58^{e}
GPC-80	39.48^{de}	MS	11.68^{d}	GPC-80	38.36^{e}	MS	12.39^{e}
Jawahar-218	29.70^{gh}	MS	11.80^{d}	Jawahar-218	30.36^{h}	MS	11.04^{f}
Ujwala	21.36^{j}	MR	13.65^{c}	Ujwala	20.42^{k}	MR	13.10^{de}
Pant C-1	31.36^{g}	MS	12.44^{cd}	Pant C-1	32.76^{g}	MS	13.12^{de}
Pusa Jwala	67.20^{a}	S	13.63^{c}	Pusa Jwala	64.50^{a}	S	13.16^{de}
Hisar Shakti	36.65^{f}	MS	12.90^{c}	Hisar Shakti	34.71^{f}	MS	12.30^{e}
Arka Lohit	24.58^{i}	MR	17.42^{b}	Arka Lohit	22.51^{j}	MR	17.10^{b}
Arka Meghana	8.60^{l}	R	23.46^{a}	Arka Meghana	8.32^{m}	R	22.38^{a}

R = Resistant, MR = Moderately Resistant, MS = Moderately susceptible, S = Susceptible HS = Highly susceptible;In the vertical columns means followed by same letters are not different statistically by Duncan Multiple Range Test (DMRT) (P = 0.05).

Table 2: In vitro evaluation of fungicides against Colletotrichum capsici

Treatments	Fungicides	Concentration (%)	Percent inhibition of mycelia growth
T1	Propineb -50WP	0.2	77.94^{g}
T2	Zineb-75 WP	0.2	74.76^{h}
T3	Propiconazole-25 EC	0.1	97.54^{a}
T4	Azoxystrobin-23EC	0.1	87.16^{d}
T5	Mancozeb-75WP	0.2	91.17^{c}
T6	Tebuconazole-25EC	0.1	93.67^{b}
T7	Copper oxy chloride- 50WP	0.3	79.40^{f}
T8	Myclobutanil-10WP	0.1	83.34^{e}
T9	Captan-50 WP	0.2	90.46^{c}
T10	Carbendazim-50 WP	0.1	71.10^{i}

Note: In the vertical columns means followed by same letters are not different statistically by Duncan Multiple Range Test (DMRT) (P = 0.01).

Table 3: In vitro evaluation of botanicals against Colletotrichum capsici

Treatments	Botanicals	Plant Parts used	Concentration (%)	Percent inhibition of mycelia growth
T1	*Lantana camera*	Leaves	15	46.40^{g}
T2	*Clerodendron inerme*	Leaves	15	55.57^{d}
T3	*Allium sativum*	Cloves	15	64.66^{b}
T4	*Durantha repens*	Leaves	15	41.46^{h}
T5	*Glyricidia maculata*	Leaves	15	28.56^{j}
T6	*Ocimum sanctum*	Leaves	15	61.67^{c}
T7	*Eucalyptus globes*	Leaves	15	35.40^{i}
T8	*Azadirachta indica*	Leaves	15	68.38^{a}
T9	*Allium cepa*	Bulbs	15	51.28^{f}
T10	*Zingiber officinale*	Rhizomes	15	53.74^{e}

Note: In the vertical columns means followed by same letters are not different statistically by Duncan Multiple Range Test (DMRT) (P = 0.01)

resistant. Pugalendhi *et al*. (2010) reported Arka Lohit genotype as moderately resistant. Ajith and Manju (2015) reported Ujwala genotype as moderately resistant.

***In vitro* evaluation of fungicides**

The results indicated that significant difference among fungicides in inhibiting the growth of the *Colletotrichum capsici.* Among ten fungicides were evaluated, Propiconazole-25 EC (97.54%) recorded maximum inhibition of mycelia growth of pathogen followed by Tebuconazole-25EC(93.67%),Mancozeb-75WP(91.17%),Captan-

Table 4: Effect of different antagonists on growth of *Colletotrichum capsici*

Treatments	*Antagonists*	*Percent inhibition of mycelia growth*
T1	*Trichoderma viride*	*51.44*[b]
T2	*Trichoderma harzianum*	*54.14*[a]
T3	*Trichoderma konnigii*	*42.50*[d]
T4	*Trichoderma virens*	*47.34*[c]
T5	*Verticillium lecanii*	*38.54*[e]
T6	*Pseudomonas fluorescence*	*20.47*[g]
T7	*Bacillus subtilis*	*29.86*[f]

Note: In the vertical columns means followed by same letters are not different statistically by Duncan Multiple Range Test (DMRT) (P = 0.01)

sanctum (61.67%), *Clerodendron inerme* (55.57%) and least inhibition was observed in *Glyricidia maculata* (28.56%)(Table3). Shinde and Gawai (2014) reported that maximum inhibition was achieved due to *Azadirachta indica* leaf extract (81.57%) followed by *Ocimum sanctum* (76.31%) and the least colony diameter was observed in *Ricinus communis* (35.52%) against Chilli anthracnose caused by *Colletotrichum capsici.*

In vitro evaluation of bio-agents

All the *Trichoderma spp* inhibited the growth of *Colletotrichum capsici* effectively. Among these antagonists *Trichoderma harzianum* showed highest inhibition (54.14%) followed by

Table 5: Efficacy of different fungicides and botanical on anthracnose of Chilli caused by *Colletotrichum capsici* during – *Kharif*, 2013.

Details of treatments	Mean PDI	Dry Pod Yield (q/ha)	Per cent yield increase over control
T1- 0.2% Propineb -50WP	31.37[c]	10.95[f]	32.08
T2-0.1% Carbendazim-50 WP	28.36[d]	11.92[e]	43.78
T3-0.2% Mancozeb-75WP	23.76[f]	16.38[a]	97.58
T4-0.1% Propiconazole-25 EC	21.50[g]	16.44[a]	98.31
T5- 0.3% Copper oxy chloride-50WP	26.10[e]	12.70[d]	53.19
T6-0.1% Tebuconazole-25EC	22.67[fg]	15.36[b]	85.28
T7-0.2% Captan-50 WP	27.48[d]	13.07[d]	57.65
T8- 0.1% Azoxystrobin-23EC	24.66[f]	14.28[c]	72.25
T9-15% *Azadirachta indica*	36.50[b]	9.94[g]	19.90
T10-Control	52.39[a]	8.29[h]	-

Note: In the vertical columns means followed by same letters are not different statistically by Duncan Multiple Range Test (DMRT) (P = 0.05).

Table 6: Efficacy of different fungicides and botanical on anthracnose of Chilli caused by *Colletotrichum capsici* during – *Kharif*, 2014.

Details of treatments	Mean PDI	Dry Pod Yield (q/ha)	Per cent yield increase over control
T1- 0.2%Propineb -50WP	32.38[c]	11.10[e]	31.2
T2-0.1% Carbendazim-50 WP	29.38[d]	12.63[d]	49.29
T3-0.2% Mancozeb-75WP	22.62[g]	15.35[b]	81.44
T4-0.1%Propiconazole-25 EC	20.79[h]	16.13[a]	90.66
T5- 0.3% Copper oxy chloride-50WP	25.84[e]	11.74[e]	38.77
T6-0.1%Tebuconazole-25EC	23.64[f]	16.51[a]	95.15
T7-0.2%Captan-50 WP	26.42[e]	13.04[d]	54.13
T8- 0.1%Azoxystrobin-23EC	24.04[f]	14.21[c]	67.96
T9-15%*Azadirachta indica*	37.39[b]	9.80[f]	15.84
T10-Control	50.64[a]	8.46[g]	-

Note: In the vertical columns means followed by same letters are not different statistically by Duncan Multiple Range Test (DMRT) (P = 0.05).

50WP(90.46%),Azoxystrobin-23EC(87.16%) and least inhibition was observed in Carbendazim-50 WP (71.10%)(Table-2). In the present study, the results obtained on efficacy of 0.1% Propiconazole-25EC and 0.1%Tebuconazole-25 EC against *Colletotrichum capsici* and *Colletotrichum dematium* causing anthracnose of Chilli and leaf spot of Soybean are in consonance with the earlier findings reported by investigators *viz*., Gopinath *et al.* (2006) and Ingle *et al.* (2014) respectively. The results on the efficacy of Mancozeb-75 WP are in conformity with Salma begum *et al.* (2015).

In vitro evaluation of botanicals

The results revealed that effect of plant extracts on the fungal growth was significant. The *Azadirachta indica* leaf extract was found effective in inhibiting the mycelia growth (68.38%) followed by *Allium sativum* cloves extract(64.66%), *Ocimum Trichoderma viride* (51.44%) and *Trichoderma virens* (47.34%).The bioagents, *Trichoderma viride*, *Trichoderma harzianum, Trichoderma virens* were reported as effective antagonists against *Colletotrichum capsici*(Kaur *et al*., 2006).Both bacterial antagonists used in the study *viz., Bacillus subtilis* (29.86%) and *Pseudomonas fluorescens* (20.47%) were moderate in controlling *Colletotrichum capsici* (Table4).

Management, *Colletotrichum capsici*

In subsequent sprays all the fungicides and botanical treated plots recorded significantly less percent disease index over control. During *Kharif*-2013, among fungicides 0.1%Propiconazole-25 EC was significantly effective in reducing the disease intensity by recording a PDI of 21.50 and dry pod yield of 16.44q/ha(Table5). 0.1%Tebuconazole-25EC,0.2%Mancozeb-75WP, 0.1%Azoxystrobin-23EC,0.3% Copper oxy chloride- 50WP and 0.2% Captan-50 WP were

next best treatments found effective in reducing the disease intensity by recording a PDI of 22.67,23.76,24.66,26.10 and 27.48 and dry pod yield of 15.36q/ha,16.38q/ha,14.28q/ha, 12.70q/ha and 13.07q/ha respectively. Again during *Kharif*-2014, among fungicides 0.1%Propiconazole-25 EC was significantly effective in reducing the disease intensity by recording a PDI of 20.79 and dry pod yield of 16.13q/ha(Table6). 0.2%Mancozeb-75WP, 0.1%Tebuconazole-25EC, 0.1%Azoxystrobin-23EC,0.3% Copper oxy chloride-50WP and 0.2% Captan-50 WP were next best treatments found effective in reducing the disease intensity by recording a PDI of 22.62,23.64,24.04,25.84 and 26.42 and dry pod yield of 15.35/ha,16.51q/ha,14.21q/ha, 11.74q/ha and 13.04q/ha respectively. Maximum PDI of 52.39,50.64 and dry pod yield of 8.29q/ha,8.46q/ha during *Kharif* 2013,2014 respectively was recorded in the control plot (Table5&6). Fungicide, Propiconazole-25EC at 0.1% was effective against anthracnose disease (*Colletotrichum capsici*) of chilli(Gopinathet *et al*., 2006 and Goswami *et al*.,2013). Fungicides, *viz*., Mancozeb-75WP, Copper oxy chloride-50WP and Captan-50WP were also reported to reduce anthracnose (*Colletotrichum capsici*) disease intensity with increased fruit yield in chilli (Akhtar,2007 and Goswami *et al.,* 2013).

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