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REACTION OF GINGER CULTIVARS AGAINST *PHYLLOSTICTA ZINGIBERI* CAUSING LEAF SPOT AND ITS MANAGEMENT

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ABSTRACT
Ten Ginger cultivars were tested, during *Kharif* 2013 and 2014 for their reaction to *Phyllosticta zingiberi* under field conditions. Humnabad local and Maran cultivars were found moderately resistant and none of them were free from the disease. Among 10 fungicides, 10 botanicals and 6 bio-agents evaluated in *in vitro* condition against *Phyllosticta zingiberi* Ramkr, Propiconazole 25 EC (92.30%) followed by Azoxystrobin 25 EC (91.70%), SAAF 75 WP (Mancozeb and Carbendazim) (89.30%), *Allium sativum* (75.70%) and *Trichoderma harzianum* (78.80%) recorded the highest inhibition of mycelial growth of *Phyllosticta zingiberi*. The field evaluation of different fungicides and botanicals during *Kharif*-2014 indicated that Propiconazole-25EC was recorded minimum PDI of 36.00 and yield of 202q/ha. Azoxystrobin-25EC,Hexaconazole-5EC,SAAF-75WP (Mancozeb-63WP and Carbendazim-12WP),Mancozeb-75WP,Propineb-50WP and *Allium sativum* cloves extract were next best treatments by recording a PDI of 40.00,45.00,46.00,50.00,55.00 and 60.00 and a yield of 185q/ha,180q/ha,179q/ha,175q/ha,173q/ha and 169q/ha respectively.Again during *Kharif* 2015, Propiconazole 25 EC was significantly superior over other treatment and similar trend was observed for other treatments also.

INTRODUCTION

Ginger (*Zingiber officinale* Rosc.) is a herbaceous perennial, the rhizomes are used as a spice and it has medicinal value agaisnt Diabetes disease in animals (Shanmugam *et al*.,2009). During 2012-13 the country produced 7.45 lakh tonnes of the spice from an area of 1.58 lakh hectares (Anonymous, 2014). India is the largest producer of ginger accounting for about one third of total world output so it is basic need to develop high yielding varieties with better quality to increase the production and productivity of ginger in India (Ravishanker *et al*., 2014). The major constraints that limit production of ginger are soft rot, yellows, rhizome rot complex, leaf spot and storage rots. Leaf spot caused by *Phyllosticta zingiberi* is one of the most threatening foliar disease, first time reported in India by Ramakrishnan (1942). Later, it was reported from Himachal Pradesh (Sohi *et al*., 1973) and Maharashtra (Kanware, 1974). Leaf spot disease of ginger leads to heavy reduction in rhizome yield through the destruction of chlorophyll tissue (Ramakrishnan, 1942). Symptoms are observed on leaves as oval to elongated spots that later turn to whitish surrounded by dark brown margin with yellow halo. Knowledge on the reaction of various ginger germplasm to leaf spot disease is very scanty. In earlier studies, Nybe and Nair (1979), Premanathan *et al*. (1980) and Dohroo *et al*. (1986) were reported the screening of some cultivars to locate the tolerance and resistant types. In the present studies, an attempt has been made to test ginger cultivars against *Phyllosticta* leaf spot and also to manage the disease. Spraying of broad spectrum fungicides like Mancozeb 75 WP, Bordeaux mixture, Chlorothalonil 75 WP and Captan 50 WP has been recommended for control of leaf spot of ginger by several workers (Sohi *et al*.,1973; Nazareno,1995; Das and Senapati,1998). Control achieved by these chemicals was inadequate. Therefore, it is thought worthwhile to test the efficacy of more promising chemicals like Propineb 50 WP, SAAF 75 WP (Mancozeb 75 WP and Carbendazim 50 WP), Propiconazole 25 EC, Hexaconazole 5 EC, Azoxystrobin 25 EC, Benomyl 50 WP against fungus. Not much light has been shed on biological control, botanicals which are effective against *Phyllosticta zingiberi*. Hence, an attempt has been made to test commonly available botanicals and bio agents against the pathogen.

MATERIALS AND METHODS

Reaction of Ginger cultivars

An experiment was conducted at College of Horticulture, Bidar, Karnataka during *Kharif* 2013 and 2014 in Randomized Complete Block Design with a plot size of 3m x 1m. Ten cultivars *viz*., Humnabad Local, Himagiri, Maran, Suprabha, Himachal, Suruchi, Suravi, ISSR-Vardha, ISSR- Mahima and ISSR-Rejitha were planted at a spacing of 20cm x 30cm (rhizome to rhizome x row to row) and all the recommended agronomic practices were followed to raise crop except fungicidal spray to avoid the killing of fungal pathogen (Anonymous, 2013). As there was heavy incidence of *Phyllosticta* leaf spot during both the years, the cultivars were scored for the disease incidence under natural field conditions without artificial inoculation. Disease score was measured,

on fifteen randomly selected leaves from each plot, by using 1-5 point rate scale (Dohroo *et al.,* 1986).

***In vitro* evaluation of fungicides**

Ten different fungicides with different modes of action were evaluated in the laboratory for their efficacy against *Phyllosticta zingiberi* by the poisoned food technique (Nene and Thapliyal, 1979). The 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 15ml 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 *Phyllosticta zingiberi* 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 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 *Phyllosticta zingiberi* at 15% concentration (Table-3).The each treatmemt 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 was followed to study interaction of six antagonists in the laboratory.Six bio-agents with a control treatment were used for evaluation (Table-4). Pour 20ml of PDA into 90mm petri dishes and allowed for solidification. Discs measuring 5mm of *Phyllosticta zingiberi* 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. A control was maintained by inoculating only *Phyllosticta zingiberi* at one end in case of fungal antagonist. In case of bacterial antagonist *Phyllosticta zingiberi* was placed at both ends of petri plates and bacterial culture was inoculated at centre of the petri plate, control was maintained by inoculating *Phyllosticta zingiberi* at the both the ends of the petri plates. Each treatment was replicated 4 times and incubated for 6 days at 27 ± 1ºC. The activity of antagonistic organisms were recorded by measuring the colony diameter of *Phyllosticta zingiberi* in each treatment and compared with control.

Management of leaf spot, *Phyllosticta zingiberi*

The field experiment was laid out in RCBD with13 treatments and 3 replications during *Kharif* 2014 and 2015 at College of Horticulture, Bidar, Karnataka. Healthy Humnabad local Ginger seed rhizome suitable to this area (Shadap *et al.,* 2013) were planted in the field with 30cm X 20cm (row to row X rhizome to rhizome) spacing in plots size of 3m X 1m. All other cultural practices and pest control practices were followed as recommended in package of practices (Anonymous, 2013). The first spray was carried out as soon as first symptom of disease was noticed in the field. 4 sequential sprays of fungicides and botanicals were taken at an interval of 15 days (Table 5 and 6). Disease severity was recorded on fifteen randomly selected leaves in each plot, just one day before each spraying and fifteen days after last spraying. Observations on severity of disease on foliage was recorded by using 1- 5 point scale and PDI was worked out as follows.

$$\text{Percent Disease Index(PDI)} = \frac{\text{Sum of individual rating}}{\text{Number of plantsor leaves examined} \times \text{maximum disease grade}} \times 100$$

The rhizome yield in each plot was recorded and computed to hectare basis, the percent increase over control was computed as follows.

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

RESULTS AND DISCUSSION

Reaction of Ginger cultivars

Ten cultivars were tested during *Kharif* 2013 and 2014 none of them were found free from the disease. All the cultivars were categorized into five different groups based on disease severity. The Humnabad local and Maran cultivars were moderately resistant and others were susceptible (Table1). At the time of harvest, rhizome yield was recorded and computed to hectare basis. No correlation between disease severity and rhizome yield among the cultivars was observed, it might be due to genetic potential of cultivars. Nybe and Nair (1979) reported that Tafingiva was the most tolerant cultivar followed by Maran. Premanathan *et al.* (1980) reported Maran and Karakkal as resistant.

***In vitro* evaluation of Fungicides**

The results indicated that significant difference among fungicides in inhibiting the growth of the *Phyllosticta zingiberi*. Among fungicides evaluated, Propiconazole-25EC recorded maximum inhibition of mycelial growth (92.30%) followed by Azoxystrobin 25 EC (91.70%), SAAF 75 WP (89.30%), Copper oxy chloride 50 WP (88.00%) and least inhibition was observed in Chlorothalonil 75 WP (51.70%) (Table-2).

Table 1: Performance of ginger cultivars against *Phyllosticta zingiberi* under field conditions

Kharif 2013 Cultivars	Disease severity (%)	Reaction	Yield (q/ha)	*Kharif 2014* Cultivars	Disease severity (%)	Reaction	Yield (q/ha)
Humnabad local	20	MR	180	Humnabad local	18	MR	177
Himagiri	35	S	139	Himagiri	32	S	143
Maran	19	MR	230	Maran	20	MR	223
Suprabha	23	S	170	Suprabha	26	S	173
Himachal	37	S	182	Himachal	35	S	189
Suruchi	30	S	123	Suruchi	28	S	129
Suravi	33	S	177	Suravi	35	S	175
ISSR-Vardha	26	S	229	ISSR-Vardha	29	S	233
ISSR-Mahima	28	S	234	ISSR-Mahima	25	S	230
ISSR-Rejitha	30	S	218	ISSR-Rejitha	27	S	223

Note: HR = Highly Resistant, R = Resistant, MR = Moderately resistant, S = Susceptible; HS = Highly susceptible

Table 2: *In vitro* evaluation of fungicides against *Phyllosticta zingiberi*

Treatments	Fungicides	Concentration (%)	Percent inhibition of mycelia growth
T1	Chlorothalonil 75 WP	0.2	51.7^{d}
T2	Propineb 50 WP	0.2	83.0^{b}
T3	Mancozeb 75 WP	0.2	85.7^{b}
T4	Copper oxy chloride 50 WP	0.3	88.0^{ab}
T5	SAAF 75 WP (Mancozeb 75 WP 50 WP) and Carbendazim	0.3	89.3^{ab}
T6	Carbendazim 50 WP	0.1	56.0^{cd}
T7	Propiconazole 25 EC	0.1	92.3^{a}
T8	Hexaconazole 5 EC	0.1	85.7^{b}
T9	Azoxystrobin 25 EC	0.1	91.7^{ab}
T10	Benomyl 50 WP	0.1	52.7^{d}

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

Table 3: *In vitro* evaluation of botanical against *Phyllosticta zingiberi*

Treatments	Botanicals	Plant Parts used	Concentration (%)	Percent inhibition of mycelia growth
T1	Parthenium hysteroporus	Leaves	15	37.0^{gh}
T2	Eucalyptus globes	Leaves	15	65.0^{c}
T3	Clerodendron inerme	Leaves	15	53.7^{d}
T4	Allium sativum	Cloves	15	75.7^{a}
T5	Zingiber officinales	Rhizomes	15	34.0^{h}
T6	Aloe vera	Leaves	15	67.0^{bc}
T7	Lantana camera	Leaves	15	42.7^{f}
T8	Durantha repens	Leaves	15	43.3^{ef}
T9	Azadirachta indica	Leaves	15	41.7^{f}
T10	Glyricidia maculata	Leaves	15	30.0^{i}

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

Table 4: Effect of different antagonists on growth of *Phyllosticta zingiberi*

Treatments	Antagonists	Percent inhibition of mycelia growth
T1	*Trichoderma viride*	67.0^{b}
T2	*Trichoderma harzianum*	78.8^{a}
T3	*Trichoderma virens*	70.0^{ab}
T4	*Trichoderma konnigii*	66.0^{b}
T5	*Pseudomonas fluorescence*	18.8^{d}
T6	*Bacillus subtilis*	32.8^{c}

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

In vitro evaluation of botanicals

The results revealed that effect of plant extracts on the fungal growth was significant. The *Allium sativum* cloves extract was found effective in inhibiting the mycelia growth (75.70%) followed by *Aloe vera* (67.00%), *Eucalyptus globes* (65.00%) and least inhibition was observed in *Glyricidia maculata* (30.00%) (Table-3).

In vitro evaluation of antagonists against *Phyllosticta zingiberi*

All the *Trichoderma* sp inhibited the growth of *Phyllosticta zingiberi* effectively. Among these antagonists *Trichoderma harzianum* showed highest inhibition (78.80%). Both bacterial

Table 5: Effect of different fungicides and botanicals on leaf spot of ginger caused by *Phyllosticta zingiberi* during *Kharif* -2014

Details of treatments	Mean PDI	Rhizome yield (q/ha)	Per cent yield increase over control
T1 -Mancozeb 75 WP	50^{fg}	175^{d}	21.53
T2-Propineb 50 WP	55^{e}	173^{de}	20.14
T3-Copper oxy chloride 50 WP	53^{ef}	174^{de}	20.83
T4- Chlorothalonil 75 WP	57^{de}	170^{de}	18.05
T5-SAAF 75 WP (Mancozeb 75 WP and Carbendazim 50 WP)	46^{g}	179^{cd}	24.30
T6-Propiconazole 25 EC	36^{i}	202^{a}	40.27
T7-Hexaconazole 5 EC	45^{h}	180^{c}	25.00
T8-Azoxystrobin 25 EC	40^{i}	185^{bc}	28.47
T9-*Eucalyptus globes*	62^{cd}	167^{e}	15.97
T10-*Allium sativum*	60^{d}	169^{e}	17.36
T11-*Aloe vera*	61^{cd}	168^{e}	16.66
T12- *Clerodendron inerme*	65^{bc}	165^{e}	14.58
T13-Control	79^{a}	144^{f}	-

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

Table 6: Effect of different fungicides and botanicals on leaf spot of ginger caused by *Phyllosticta zingiberi* during *Kharif* -2015

Details of treatments	Mean PDI	Rhizome yield (q/ha)	Per cent yield increase over control
T1 -Mancozeb 75 WP	50^{e}	174^{cd}	20.00
T2-Propineb 50 WP	51^{e}	176^{c}	21.37
T3-Copper oxy chloride 50 WP	54^{de}	175^{c}	20.68
T4- Chlorothalonil 75 WP	56^{cd}	173^{cd}	19.31
T5-SAAF 75 WP (Mancozeb 75 WP and Carbendazim)	48^{e}	180^{b}	24.31
T6-Propiconazole 25 EC	35^{g}	203^{a}	40.00
T7-Hexaconazole 5 EC	44^{f}	182^{b}	25.51
T8-Azoxystrobin 25 EC	42^{f}	183^{b}	26.20
T9-*Eucalyptus globes*	64^{b}	170^{d}	17.24
T10-*Allium sativum*	58^{c}	171^{d}	17.93
T11-*Aloe vera*	62^{b}	165^{e}	13.80
T12- *Clerodendron inerme*	63^{b}	167^{e}	15.17
T13-Control	80^{a}	145^{f}	-

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

antagonists used in the study *viz., Bacillus subtilis* (32.80%) and *Pseudomonas fluorescens* (18.80%) were moderate in controlling *Phyllosticta zingiberi* (Table 4).

Management of leaf spot, *Phyllosticta zingiberi*

In subsequent sprays all the fungicides and botanicals treated plots recorded significantly less disease index over control. During *Kharif*-2014, among fungicides 0.1%Propiconazole-25EC was significantly effective in reducing the disease by recording a PDI of 36.00 and a yield of 202q/ha(Table-5). 0.1% Azoxystrobin-25EC,0.1% Hexaconazole-5EC, 0.2% SAAF-75 WP (Mancozeb-63WP and Carbendazim-12WP), 0.2% Mancozeb-75WP and 0.2% Propineb-50 WP were next best treatments found effective in reducing the disease intensity by recording a PDI of 40.00, 45.00, 46.00, 50.00 and 55.00 and a yield of 185q/ha, 180q/ha, 179q/ha, 175q/ha and 173q/ha, respectively. Among botanicals tested, mimimum PDI of 60.00 and yield of 169q/ha was recorded in *Allium sativum* cloves extract(15%) and maximum PDI of 79.00 and yield of 144q/ha was recorded in the control plot(Table-5). Again during *Kharif* 2015, Propiconazole 25 EC was significantly superior over other treatment and similar trend was observed for other treatments also (Table-6). Sohi *et al*., 1973 reported that Copper oxy chloride 50 WP and Mancozeb 75 WP were effective against *Phyllosticta zingiberi* and gave maximum yield per ha.

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