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RESEARCH ARTICLE

Survival of *Colletotrichum truncatum* in seeds and crop debris of greengram [*Vigna radiata* (L.) Wilczek]

■ SUNIL KULKARNI[1*] AND V. I. BENAGI[2]

[1*]Department of Plant Pathology, Krishi Vigyan Kendra, [U.A.S.(R.)], BIDAR (KARNATAKA) INDIA
[2]Department of Plant Pathology, University of Agricultural Sciences, DHARWAD (KARNATAKA) INDIA

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*Corresponding author:
kvksunil@gmail.com

ABSTRACT

The per cent viability of conidia of *Colletotrichum truncatum* in crop debris was significantly affected by duration of storage as well as different storage conditions. The conidia survived for a maximum of 360 days under freeze (4 - 5^{0}C) conditions and least survivability of 90 days under field condition (28 - 30^{0}C). In case of infected seeds, the pathogen survived up to the next crop season (12 months) but the survivability decreased with lapse of time. However, the germination percentage of the seeds increased with storage time.

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INTRODUCTION

Greengram [*Vigna radiata* (L.) Wilczek] is one of the important pulse crops of India and is cultivated in 32.99 lakh ha with production of 13.74 lakh tonnes with a productivity of 417 kg per ha, while in Karnataka, the area under greengram was 1.77 lakh ha and production of 0.71 lakh tonnes and productivity of 399 kg per ha (Rajendra Prasad, 2006).

The average yield of greengram in our country is very low. It has the yield potential of 11 to 12 q per ha (Anonymous, 2004), as against the national average of 4.17 q per ha. Among various factors responsible for low yields, biotic and abiotic stresses take a heavy toll of the crop, out of which anthracnose disease causes an estimated yield losses of 18.2 to 86.57 per cent (Laxman,2006).

Seed plays a vital role in the production of healthy crop .Seed borne disease of greengram like anthracnose caused by *Colletotrichum truncatum* (Schw.) Andrus and Moore has been reported from all regions of India in mild to severe form. It causes considerable damage by reducing seed quality and yield. Information with respect to the mode of survival of the pathogen from one season to another is hardly available in the literature. Therefore, attempts were made during 2007-08 post crop season to observe the role of infected seeds and crop debris in the perpetuation of the pathogen from season to season.

MATERIALS AND METHODS

The present investigation on viability and survival of *C. truncatum* was undertaken during 2007-08 at Agricultural College, Dharwad (Karnataka) to obtain the information about the perpetuation of the pathogen during the off season. Fresh leaves of greengram plants infected with anthracnose were collected and stored in paper bags under different storage conditions *viz*., freeze (4 – 5^{0}C), under tree shade (18 – 22^{0}C), room temperature (20 – 25^{0}C), glasshouse (25 – 28^{0}C) and field conditions (28 -30^{0}C) in separate lots.

Per cent germination of conidia on each type of stored leaf was recorded before their preservation. The viability of conidia on leaf under different storage conditions was regularly examined at 15 days interval by checking the germination under microscope.

To study the survival of pathogen on infected seeds obtained from naturally infected pods of greengram were initially sun dried for a week and stored at room temperature.

The seed samples were drawn at regular monthly interval and each time 400 seeds were subjected to standard blotter test in two replications to evaluate *C. truncatum* seed infection. Similarly, viability of greengram seeds during each observation was recorded by subjecting 100 seeds from each seed sample to standard germination test and per cent germination was worked out (Anonymous, 1996).

RESULTS AND DISCUSSION

The observations (Table 1) revealed that, per cent viability of conidia decreased with increase in storage period in all conditions tested. The conidia remained viable for 120 days when kept under glasshouse conditions, whereas they remained viable for 210 days at room conditions. Similarly, the viability of conidia, remained for 240 days under tree shade condition. Maximum period of viability of spores remained upto 360 days under freeze condition. The lowest period of viability of conidia remained for 90 days under field conditions.

Earlier, Tu (1983) reported that longevity of *C. lindemuthianum* varied greatly depending on environmental conditions. Moisture had a profound effect on its longevity. The fungus survived for at least five years in infected pods of bean that were air dried and kept in storage at 4^0C. Under natural field condition, there was rapid decrease in viability of conidia under wet conditions which may be attributed to the loss of the mucilaginous water soluble matrix of the conidia.

The survival of fungus through infected seeds (Table 2) revealed that there was a sharp decline in survivability of the fungus over the period of storage, however the germination percentage increased with the time. Further, it was observed that initially *C. truncatum* fungus recorded 23.5 per cent survival in seed after 30 days of storage. Later, there was a gradual decrease in the survivability of fungus. The fungus remained viable at low percentage (7.3) upto 360 days. The germination percentage gradually increased with the increase in the storage period and reached upto 87 per cent after 360 days of storage. However ,the difference was significant

Table 1: Studies on survival of conidia of *Colletotrichum truncatum* on greengram leaves under different storage conditions

Storage period (days)	Per cent viable conidia under different storage conditions				
	Freeze ($4\text{-}5^0$C)	Tree shade ($18\text{-}22^0$C)	Room/Lab ($20\text{-}25^0$C)	Glass house ($25\text{-}28^0$C)	Field ($28\text{-}30^0$C)
15	87.2	82.2	80.2	76.7	66.2
30	85.8	76.5	77.3	68.2	57.2
45	83.2	70.2	73.1	61.2	42.3
60	80.4	67.9	69.6	55.2	30.8
75	77.5	63.4	65.3	46.3	15.2
90	73.6	54.7	56.8	23.1	2.9
105	70.8	48.3	50.4	10.4	0
120	67.5	40.1	42.4	2.2	0
135	63.8	35.7	36.9	0	0
150	60.1	30.2	29.2	0	0
165	57.8	25.4	21.7	0	0
180	54.2	20.8	15.4	0	0
195	51.4	17.2	10.8	0	0
210	48.6	13.9	3.3	0	0
225	45.9	8.1	0	0	0
240	41.3	5.3	0	0	0
255	38.2	0	0	0	0
270	35.8	0	0	0	0
285	34.5	0	0	0	0
300	30.2	0	0	0	0
315	29.0	0	0	0	0
330	25.2	0	0	0	0
345	20.2	0	0	0	0
360	5.2	0	0	0	0

between the initial and last stages of the experiment.

Table2 : Studies on survival of *Colletotrichum truncatum* in greengram seeds and its effect on germination

Storage period (in days)	Percent survival of fungus	Percent germination of seed
30	23.5	54
60	22.2	55
90	22.0	57
120	24.0	57
150	18.8	60
180	17.1	63
210	14.0	66
240	13.5	69
270	13.0	74
300	10.8	76
330	9.0	81
360	7.3	87
C.D. at 5%	3.67	5.91

Rajkumar *et al.* (1989) had earlier reported decrease in survivability of the pathogen through seeds with increase in storage period and a corresponding increase in germination of seeds with time. Decline in survivability may be due to factors like depletion of nutrients in seeds, low moisture as well as poor saprophytic ability of the pathogen. Increase in germination of seeds with time might be the result of decline in survivability of fungus with the increase in storage period.

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RESEARCH ARTICLE

In vitro evaluation of chemicals, botanicals and bioagents against the bacterial blight of pomegranate caused by *Xanthomonas axonopodis* pv. *punicae*

■ J. RAJU*, V. I. BENAGI, K. JAYALAKSHMI, V. B. NARGUND AND PRITI S. SONAVANE

Department of Plant Pathology, College of Agriculture, University of Agricultural Sciences, DHARWAD (KARNATAKA) INDIA

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*Corresponding author:
rajuj.smg@gmail.com

ABSTRACT

Bacterial blight of pomegranate caused by *Xanthomonas axonopodis* pv. *punicae* has become potentially destructive disease. An investigation was carried out to screen the different bactericides, bioagents and botanicals to inhibit the pathogen. Among the different chemicals, Streptocycline + COC with an inhibition zone of 3.3cm exhibited superior efficacy followed by Streptocycline (2.80cm) and COC (2.65cm). From the botanicals Tulsi leaves followed by Neem seed oil, Garlic bulb extract and Patchouli leaves were found effective. From the different antagonists, it was observed that *Bacillus subtilis* and *Pseudomonas fluorescens* were found significantly superior over other antagonists in inhibiting the growth of the pathogen.

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INTRODUCTION

Pomegranate (*Punica granatum* L.) is an ancient fruit, belonging to the smallest botanical family Punicaceae, which is the native of Iran. It is regarded as the "Fruit of paradise". It is one of the most adaptable subtropical minor fruit crops and its cultivation is increasing very rapidly. In India, it is regarded as a "vital cash crop". Successful cultivation of pomegranate in recent years has met with different traumas such as pests and diseases. Among various diseases, bacterial blight caused by *Xanthomonas axonopodis* pv. *punicae* (Vauterin *et al*., 1995) is a major threat of pomegranate that reduces fruit quality to a greater extent.

MATERIALS AND METHODS

***Inhibition zone assay method* :**

The bacterium was multiplied by inoculating the culture into 20 ml of nutrient broth taken in 'Erleyenmayers' flask. The inoculated flasks were incubated at 30^{0}C for 72 hours. The bacterial suspension was then seeded to the lukewarm Nutrient agar medium (1000 ml). The seeded medium was poured into the sterilized Petriplates and plates were allowed to solidify. The filter paper discs (Whatman No. 42) measuring 5 mm in diameter were soaked in the respective chemical solution for 5 minutes and transferred onto the surface of the seeded medium in Petriplates. The inoculated plates were kept in the refrigerator at 5^{0}C for 4 hours to allow the diffusion of chemical into the medium. Then plates were incubated at 30^{0}C for 72 hours and observed for the production of inhibition zone around the filter paper discs.

Four biocontrol agents *viz., Trichoderma viride*, *Trichoderma harzianum*, *Pseudomonas fluorescence* and *Bacillus subtilis* were evaluated for their efficacy against the growth of *X. axonopodis.* pv. *punicae* by inhibition zone assay

method. The cultures / formulations of these biocontrol agents were obtained from Department of Plant Pathology, University of Agricultural Sciences, Dharwad and Institute of Organic Farming, Dharwad. A loopful culture of each of the antagonistic organism was placed in the centre of Petriplates containing the seeded medium. The inoculated plates were then incubated at 30^0C for 72 hours. Observations were recorded for the zone of inhibition produced by the antagonistic micro organisms around the growth of the pathogen.

For botanicals, fresh plant materials were collected and washed first in tap water and then in distilled water. 100 g of fresh sample was chopped and macerated in a surface sterilized pestle and mortar by adding 100 ml of sterile water (1:1 w/v). The extract was filtered through two layers of muslin cloth; filtrate thus, obtained was used as a stock solution. Ten, twenty, thirty and forty per cent each of plant extract was prepared by mixing 10, 20, 30 and 40 ml of stock solution with 90, 80, 70 and 60 ml of sterilized distilled water, respectively. To study the antibacterial mechanism of plant extracts, inhibition zone assay method was followed.

RESULTS AND DISCUSSION

Among different chemicals and their combinations, Streptocycline + copper oxychloride showed the highest inhibition (2.8 cm) followed by copper oxychloride (2.62 cm) which were on par with each other. All other chemicals *viz*., Streptocycline + copper hydroxide, copper hydroxide were found to be moderately effective but were significantly different from each other, Bacterinol and Kasagumycin were less effective and were on par with each other (Table 1). Between the concentrations of each chemical, efficacy was

Table 1: *In vitro* evaluation of chemicals against *Xanthomonas axonopodis* pv. *Punicae,* causal agent of bacterial blight of pomegranate

Sr. No.	Trade name of the chemical	Concentration (ppm)	Mean diameter of inhibition zone (cm)
1.	Bacterinol	250	0.67 (1.29)*
		500	0.72 (1.31)
		750	0.82 (1.34)
2.	Copper oxychloride (coc)	1500	2.62 (1.90)
		2000	2.62 (1.90)
		2500	2.65 (1.91)
3.	Copper hydroxide	1500	1.77 (1.66)
		2000	1.82 (1.67)
		2500	1.82 (1.67)
4.	Kasagumycin	250	0.55 (1.24)
		500	0.55 (1.24)
		750	0.65 (1.28)
5.	Streptocycline	250	2.37 (1.83)
		500	2.60 (1.89)
		750	2.80 (1.94)
6.	Streptocycline + Copper oxychloride	250 +1500	2.40 (1.84)
		500 +2000	2.75 (1.93)
		750 +2500	3.30 (2.07)
7.	Streptocycline + Copper hydroxide	250 +1500	2.10 (1.76)
		500 +2000	2.17 (1.78)
		750 +2500	2.40 (1.84)
8.	Pathonil	2500	1.15 (1.46)
		5000	1.42 (1.55)
		7500	1.60 (1.61)
9.	Untreated control		0.00 (1.00)
		S.E.±	CD at 1%
		0.02	0.08

* Figures in parenthesis are transformed values $\sqrt{x+1}$

significant from lower to higher concentration with greater efficacy at higher concentrations.

Interaction effect among the chemicals and concentration indicated that, Streptocycline (750 ppm) + COC (2500 ppm) and Streptocycline at 750 ppm were highly effective with an inhibition zone of 3.3 cm and 2.8 cm, respectively followed by COC 2500 ppm. The moderately effective treatments were Streptocycline (750 ppm) + copper hydroxide at 2500 ppm (2.4 cm), copper hydroxide at 2000 ppm (1.82), Pathonil at 7500 ppm (1.6cm), Kasagumycin at 750 ppm (0.65cm), of which Pathonil and Kasagumycin were on par with each other. Bacterinol at 250 ppm (0.67cm) and Kasagumycin at 250 ppm (0.55cm) were also on par with each other. The present findings are in agreement with Sharma *et al.* (1981), who reported that the combination of Streptocycline and copper sulphate was most effective in inhibiting the growth of *Xanthomonas vesicatoria* as assessed by *in vitro* paper disc method. Manjula *et al.* (2002) also recorded the highest inhibition zone produced by Paushamycin (0.05%) against the growth of *Xanthomonas axonopodis* pv. *punicae*. Bactrinol (0.05%) and Bacteriomycin were the next best effective chemicals and Kasugamycin @ 500 ppm concentration was least effective.

Out of seven botanicals evaluated against *Xanthomonas axonopodis* pv. *punicae*, Tulsi leaf extract at 40 per cent concentration showed maximum inhibition (1.76 cm) followed by Neem seed oil (1.50cm) (Table 2). Garlic bulb, Meswak stem and leaves of patchouli extracts were found to be on par at 30 per cent concentration. However, custard apple seed extract and leaves and stem extract of adathoda showed no effect on *Xanthomonas axonopodis pv. punicae* at all concentration tested.

Interaction effect among the botanicals and concentration indicated that, Tulsi leaves was found to be most effective at 40 per cent with (1.76 cm) inhibition zone and the next best botanicals were Neem seed oil at 40 per cent concentration (1.50 cm) followed by Garlic bulb (1.10 cm). The moderately effective treatments were patchouli at 40 per cent concentration (0.88cm) and Meswak powder at 40% (0.89cm), where as Adathoda and custard apple were found ineffective. Srinivasachary (1995) reported Ocimum plant extract as most effective botanical against the growth of *Xanthomonas campestris* pv. *mori* isolated from mulberry. Similar results were found in the present investigation.

Table 2: *In vitro* evaluation of botanicals against *Xanthomonas axonopodis* pv. *Punicae*, causal agent of bacterial blight of pomegranate

Sr. No	Name of the botanical	Plant part used	Mean diameter of inhibition zone (cm) Concentration (%)			
			10	20	30	40
1.	*Adathoda vasica* (Adathoda)	Leaves and stem	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
2.	*Annanosa squamosa* (Custard apple)	Seeds	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
3.	*Alium sativum* (Garlic)	Bulb	0.80 (1.34)	0.82 (1.34)	0.85 (1.36)	1.10 (1.44)
4.	*Azadirachta indica* (Neem)	Seed oil	0.80 (1.34)	1.00 (1.41)	1.22 (1.48)	1.50 (1.58)
5.	*Salvadora persica* (Meswak)	Stem	0.63 (1.27)	0.70 (1.30)	0.84 (1.35)	0.89 (1.37)
6.	*Pogostemon cablin* (Patchuoli)	Leaves	0.67 (1.29)	0.72 (1.31)	0.82 (1.34)	0.88 (1.37)
7.	*Ocimum sanctum* (Tulsi)	Leaves	0.70 (1.30)	0.70 (1.30)	1.62 (1.61)	1.76 (1.66)
8.	Control		0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
	Factors	S.E.±	C.D. at 1%			
	Botanicals	0.03	0.13			
	Concentration	0.02	0.09			
	Interaction	0.07	0.26			

* Figures in parenthesis are transformed values $\sqrt{x+1}$

Table 3 : *In vitro* evaluation of antagonists against the growth of *Xanthomonas axonopodis* pv. *Punicae*

Sr. No.	Antagonistic organism	Mean diameter of inhibition zone (cm)
1.	*Bacillus subtilis*	0.67 (1.29)
2.	*Psuedomonas flourescens*	1.77 (1.66)
3.	*Trichoderma viride*	0.00 (1.00)
4.	*Trichoderma harzianum*	0.00 (1.00)
5.	Control	0.00 (1.00)
	S.E.±	0.02
	C.D. at 1%	0.10

* Figures in parenthesis are transformed values $\sqrt{x+1}$

Study conducted on effect of antagonistic agent on growth of *Xanthomonas axonopodis* pv.*punicae* (Table 3) indicated that among the four antagonistic agents tested, *Pseudomonas flourescens* was found significantly superior in inhibiting the growth of organism (1.77 cm) followed by *Bacillus subtilis* (0.67 cm). However, *Trichoderm viride* and *Trichoderma harzianum* were found ineffective as they failed to inhibit the growth of *Xanthomonas axonopodis* pv. *punicae*. These findings are confirmed by the results of Unnamalai and Gnanamanickam (1984) who reported the inhibiting effect of *Pseudomonas fluorescens* on the growth of *Xanthomonas citri*.

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RESEARCH ARTICLE

Evaluation of promising groundnut genotypes for yield and their reaction to leaf spot diseases in North coastal zone of Andhra Pradesh

■ V. MANOJ KUMAR[1]*, N. HARISATYANARAYANA[1] AND K. MADHU KUMAR[1]

*Department of Plant Pathology, Agricultural College, (A.N.G. R.A.U.), BAPATLA (A.P.) INDIA
[1](A.N.G.R.A.U.), Agricultural Research Station, Amadalavalasa, SRIKAKULAM (A.P.) INDIA

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*Corresponding author:
valaparla_mvk@rediffmail.com

ABSTRACT

Field trials were conducted at Agricultural Research Station, Amadalavalasa for three consecutive *Kharif* seasons of 2009-2010 , 2010-2011 and 2011-2012 to evaluate sixteen promising genotypes (inclusive of Abhaya as check) for yield and their reaction to early and late leaf spots under natural (unprotected) conditions in Randomized Block Design(RBD) with three replications of 20 sq.m. plot. Observations on dry pod yield, shelling per cent and dry haulm yield were recorded after harvesting. Early leaf spot and late leaf spot observations were recorded from natural initiation of disease up to harvest at 20 days interval and genotypes were categorized based on 1-9 scale. Significantly highest average dry pod yield and shelling per cent was recorded in FDR 79(1860.53 kg/ha and 68.50%) and TCGS 894 (1804.53 kg/ha and 67.56%). Out of 16 genotypes evaluated for their reaction to leaf spot diseases, early leaf spot disease was recorded in the range of 6.83 per cent (FDR-79) during *Kharif* 2009-2010 up to 51.9 per cent (DRT 43) during *Kharif*-2010-2011. FDR-79 has resistant reaction to early leaf spot for three consecutive years with severities of 6.83, 9.48 and 8.95 per cent during 2009-2010, 2010-2011 and 2011-2012, respectively, mean severity was also observed to be lowest (8.42%), hence, the entry has resistant reaction to early leaf spot among the genotypes evaluated under natural field conditions. Late leaf spot was observed in the range of 10.00 per cent (FDR-79) during *Kharif*-2011-2012 up to 48.00 per cent (TCGS 983) during 2011-2012 and none of the entries was resistant to late leaf spot. FDR 79 and TCGS 894 were found to be superior and suitable genotypes for North coastal zone of Andhra Pradesh.

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INTRODUCTION

Groundnut is gaining popularity among North coastal zone farming community of Andhra Pradesh in the recent past and is being cultivated extensively in *Kharif* season in an acerage 45000 ha. with yield of 49000 MT and with productivity of 1076 kg/ha (Anonymous, 2010-11). High yielding, pest and disease resistant and adoptable varieties are very much needed in the present scenario. Among the biotic production constraints, diseases are quite important constraints in groundnut crop from sowing to harvesting. Early leaf spot caused by *Cercospora arachidicola* Hori and late leaf spot caused by *Phaeoisasariopsis personata* (Berk. and Curt.) v. Arx are important among diseases and often result in severe defoliation which is ignorantly linked to maturity by farmers resulting in almost 80 per cent of the leaves on groundnut plants are defoliated due to combined attack of Cercospora leaf spot diseases (Ize *et al.,* 2007). Hence an attempt was made to evaluate the selective promising genotypes from Kadiri and Tirupathi ground nut research

stations, Andhra Pradesh for their yield and their reaction against the leaf spot diseases in North coastal zone of Andhra Pradesh.

MATERIALS AND METHODS

Experimental trials were conducted for three consecutive *Kharif* seasons from 2009-2012 at Agricultural Research Station, Amadalavalasa having light red sandy loamy soils, poor in organic matter, soil pH 5.5-6.5, nutritional status of nitrogen 216-297, phosphorus14.8 -25.0 and potassium 183-250 kg/ha. with a total average rainfall of 802.23 mm received for the past 10 years.

Trials were conducted in Randomized Block Design in three replications with plot size of 20 sq.m(Gomez and Gomez, 1984), 20 kg nitrogen in the form of urea, 50 kg phosphorus as single super phosphate and 40 kg potash in the form of murate of potash + 500 kg gypsum (at early flowering stage) were applied per hectare, no fungicidal sprays were taken up in these trials.

Sixteen promising genotypes from Agricultural Research Station, Kadiri and Tirupathi were evaluated for their yield performance and their reaction to early and late leaf spots under natural conditions. Observations on shelling per cent (kernel to shell weight ratio), dry haulm yield(depoded and dried plants weight) and dry pod yield were recorded after harvest. Observations in 20 randomly selected plants per plot on early and late leaf spot were recorded on all entries at 20 days interval from disease initiation to till harvest. Symptomatology based differentiation was done to differentiate early and late leaf spots at maturity to avoid misinterpretation of observations. Scoring was given to main stem only by dividing it into 3 parts as bottom, middle and top based on number of branches. Based on the severity of leaf lesions, defoliation on bottom, middle and upper portion of plants, 1-9 common scale was adopted for both diseases as per Subrahmanyam *et al.*(1995) given below :

RESULTS AND DISCUSSION

Significantly highest average dry pod yield (1860.53 kg/ha.) and shelling per cent (68.59%) was recorded in FDR 79 followed by TCGS 894 (1804.53 kg/ha and 67.56%) (Table 1 and Fig..1 and 2) and were at par, shelling per cent of Abhaya (check) (68.72%) was at par with aforementioned genotypes. K 1468, K 1470 and K 1482 have yielded significantly highest average dry haulm of 3749.0, 3868.9 and 4130.5 kg/ha, respectively and were at par with each other (Table 1) ascertaining their dual purpose value of food and fodder.

Among 16 genotypes evaluated for their reaction to leaf spot diseases, early leaf spot disease was recorded in the range of 6.83 per cent (FDR-79) to 53.0 per cent (K 1470) during *Kharif* 2009, 9.48 per cent (FDR-79) to 42.93 per cent (DRT-43) in *Kharif*-2010 and 8.95 per cent (FDR-79) to 37.87 per cent (K-1452) in *Kharif*-2011. The genotype FDR -79 has resistant reaction to early leaf spot for three consecutive years with severities of 6.83, 9.48 and 8.95 per cent during 2009-2010, 2010-2011 and 2011-2012, respectively with mean severity of 8.42 per cent (Table 2 and Fig.3). Mean reaction of 14 genotypes were moderately resistant and K-1452 was susceptible to early leaf spot. Late leaf spot was observed in the range of 10.00 per cent (FDR-79) to 49.8 per cent (TCGS 983) during 2011-2012, however, FDR-79 has recorded lowest mean severity of 22.3 per cent and it has resistant reaction (10.00%) during *Kharif*-2011-2012. FDR-79 was observed to showed comparatively less susceptible to late leaf spot disease. Among the 16 genotypes screened against late leaf spot diseases, six were moderately resistant, one was moderately susceptible and nine were susceptible. The genotype FDR-79 resistant to early leaf spot and moderately resistant to late leaf spot can be used for developing the leaf spot resistant varieties in groundnut.

Ruben and Mrema (1990) reported that shelling per cent was moderately but significantly ($p<0.05$) correlated ($r=0.57$) with yield and it is in concurrence with the present research

Scale	Description	Severity(%)
1.	No disease	0
2.	Lesions present largely on lower leaves, no defoliation	1-5
3.	Lesions present largely on lower leaves, very few on middle leaves, defoliation of some leaflets, evident on lower leaves	6-10
4.	Lesions present on all lower leaves and middle leaves, over 50% defoliation of lower leaves	11-20
5.	Lesions present on all lower leaves and middle leaves, over 50% defoliation on lower leaves	21-30
6.	Severe lesions present on all lower leaves and middle leaves, lesions present but less severe on top leaves; extensive defoliation of lower leaves, defoliation of some leaflets, evident on middle leaves	31-40
7.	Lesions on all leaves but less severe on top leaves, defoliation of all lower leaves and some middle leaves.	41-60
8.	Defoliation of all lower and middle leaves, severe lesions on top leaves, some defoliation of top leaves evident	61-80
9.	Almost all leaves defoliated, leaving bare stem, some leaflets may remain but showing severe leaf spots	81-100

Based on the aforementioned scale, genotypes were catagorized into resistant- 1-3 scale; Moderately resistant: 4-6 scale; Susceptible: 7-9 scale

Table 1 : Yield attributes of promising genotype

Entry	Dry pod yield (kg/ha)				Shelling (%)				Dry haulm yield (kg/ha.)			
	2009	2010	2011	Mean	2009	2010	2012	Mean	2009	2010	2011	Mean
K-1392	1453.9	444	2450	1449.3	64.67	63.00	63.38	64.38	3644.4	2172	1455	2423.8
TCGS 894	1898.6	1082	2433	1804.53	70.67	65.33	65.56	67.56	3377.7	1791	1170	2112.9
K 1451	1788.7	871	2261	1640.23	68.67	64.33	64.46	66.46	3407.4	2897	1369	2557.8
TCGS 983	1466.7	877	2261	1534.90	67.67	63.67	63.17	65.17	3431.1	2180	1484	2365.0
K-1452	1842.3	726	2124	1564.10	66.67	60.67	60.22	63.22	3602.9	3303	1807	2904.3
TCGS 983-1	1429.0	646	2353	1476.00	67.67	65.33	65.25	66.25	3588.1	2373	1804	2588.3
K-1454	1624	751	2640	1671.66	64.67	67.33	67.48	66.48	4447.4	3265	1760	3157.4
FDR-79	2106.6	1034	2441	1860.53	70.67	61.0	61.99	68.59	5925.9	2110	1161	3065.6
K 1463	1469.9	643	2083	1398.63	69.67	66.67	66.59	65.99	4764.4	2142	1132	2679.4
ABHAYA(c)	1677.3	707	2086	1490.10	71.67	66	66.72	68.72	5333.3	3464	1481	3426.1
K 1468	1504.5	913	1274	1230.5	65.67	60.33	60.86	62.86	5822.2	4151	1274	3749.0
KADIRI 6	1367.1	723	2707	1599.03	73.67	60.33	60.83	65.83	4020.7	2207	1274	2500.5
K 1470	1250.6	418	2332	1333.53	66.67	61.67	61.77	63.77	5608.8	3879	2119	3868.9
KADIRI 9	1778.0	886	2246	1636.66	71.67	61.00	61.49	65.49	4136.2	3197	1911	3081.4
K 1482	1637.3	951	2127	1571.76	67.67	64.00	64.81	65.81	6349.63	4323	1719	4130.5
DRT 43	2140.1	1164	1013	1439.03	65.67	65.00	65.47	65.45	4026.66	3111	1520	2885.8
S Em±	144.77	176.75	137.13	195.54	1.21	1.41	1.45	1.28	562.9	362.5	102.49	503.61
C.D.	398.1	510.42	397.13	564.68	3.51	4.07	4.18	3.71	1548.0	1046.8	295.96	1384.9
	(0.01)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.01)	(0.05)	(0.05)	(0.01)

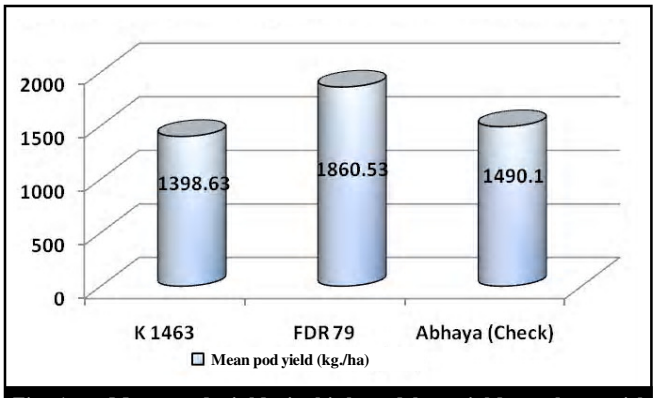

Fig. 1 : Mean pod yields in high and low yielders along with check

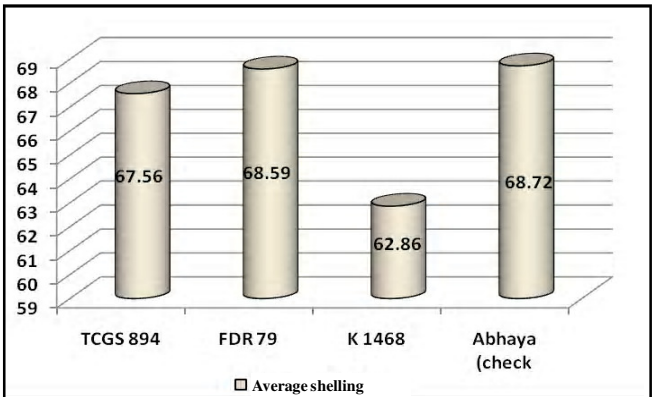

Fig. 2 : Average shelling per cent in respective genotypes

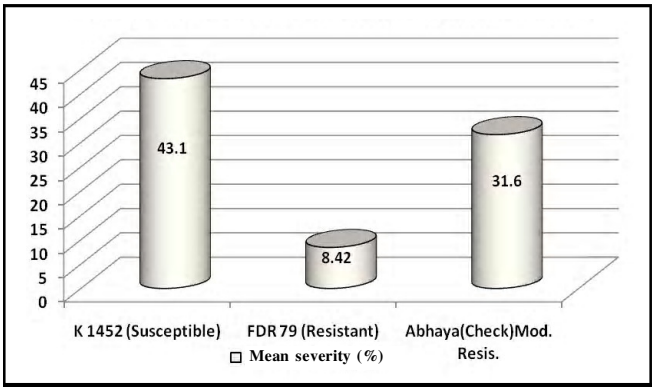

Fig. 3 : Trend of mean severity in susceptible, resistant and chck

findings. On-farm verification of three new groundnut varieties in Zambia, Kanenga(1990) has elucidated that during first season MGS 2 gave higher yield than control in all locations, MGS 3 was found superior in the yield to MGS 2 in second season. Hossain *et al.* (2007) reported that M-9, NCAC-17090, 259/88, 262/88 and 269/89 showed moderately resistant reaction against leaf spot in two different locations and existence of differential reaction under infector-row screening, genotypes 255/8 and 264/89 were moderately resistant in one location and moderately susceptible in another location and similar observations were made by Paningbaton(1980). Izge *et al.* (2007) reported significant levels of susceptibility of varieties to Cercospora leaf spot, the varieties ICGV-IS-96802, ICGV-IS-96827and ICGV-IS-96808 recorded lowest susceptibility to Cercospora disease incidence, highest haulm yield was produced by ICGV-SM-93531, ICGV-I S-96827, ICGV-IS-96802 and ICGV-IS-96801, highest kernel yield and lowest leaf spot diseases were recorded in ICGV-IS-96808. Highest dry pod yield and resistant reaction to early leaf spot in FDR 79 in the present research findings is in conformity with Izge *et al.*(2007) . Rao and Mkhabela (1990) reported that ICGV-SMs 85001, 85053, 86014 and 86053 were satisfactorily high yielding and has disease tolerance to leaf spots and rusts.

TCGS 894 and FDR 79 have yielded significantly high dry pod weight compared to the rest over three *Kharif* seasons, TCGS 894 despite having moderate resistant reaction to early and late leaf spots has yielded at par with FDR 79, genotype FDR 79 was the lone resistant genotype to early leaf spot and high yielding. Both the entries can have greater prospects for North coastal zone of Andhra Pradesh state.

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RESEARCH ARTICLE

Genetic diversity of *Ralstonia solanacaerum* from major tomato growing areas of Karnataka

■ K. SUMANGALA*, S. LINGARAJU, YASHODA R. HEGDE AND A.S. BYADAGI

Department of Plant Pathology, College of Agriculture, University of Agricultural Sciences, DHARWAD (KARNATAKA) INDIA

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*Corresponding author:
sumakoulagi@gmail.com

ABSTRACT

Ralstonia solanacearum isolates from Karnataka (India) were analyzed by random amplified polymorphic DNA technique,the data distinguished the isolates into seven major clusters.High level of polymorphism (73.93%) indicated diverse genetic base. Maximum genetic diversity of 0.61 per cent was observed between Hosalli (Rs-7) and Doddaballapur (Rs-9) isolates, Distribution of strains into genetic clusters did not relate to geographic origin.

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INTRODUCTION

Ralstonia solanacearum(Yabucchi *et al.,* 1995), a causal agent of bacterial wilt of several crops like potato, tomato, pepper, tobacco, etc. is one of the important disease causing organisms in tropical, subtropical and warm temperate regions of the world (Hayward, 1991). *R. solanacearum* embraces a diverse array of populations that differ in host range, geographical distribution, pathogenicity, genetic and physiological properties. To describe this intra-specific variability, binary classification systems are used. There is considerable genetic variation among strains within each race or biovar (Cook *et al.,* 1989). In recent years, research has been directed towards developing rapid, sensitive and specific diagnostic assays to detect the *R. solanacearum* in plant and soil samples (Baker *et al.* 1984; Hendrick and Sequiera, 1984). Random amplified polymorphic DNA (RAPD) analysis (Williams *et al.,* 1990) has many advantages such as speed, low cost, minimal requirement of DNA, and lack of radioactivity, as a means of characterizing genetic variability. Major polymorphisms in RAPD pattern indicate genetic distinctness which can be used to distinguish unrelated groups. Minor polymorphisms may indicate genetic distinctness within groups or may occur because of experimental variability and, therefore, must be verified by repetition. RAPD analysis has been used effectively to distinguish between *R. solanacearum* strains.

MATERIALS AND METHODS

Laboratory experiments were carried out at the Department of Plant Pathology and Institute of Agri - Biotechnology (IABT), College of Agriculture, University of Agricultural Sciences, Dharwad. Karnataka (India), during 2008-2010. *Ralstonia* affected samples were collected from twenty four locations from major tomato growing areas of Karnataka. The details of location and designation given for each isolates are furnished in Table A. The pathogen was isolated on tetrazolium chloride (TZC) medium. Typical mucoid, creamy white colonies with pink centre was observed on medium ofter 48 h incubation and such single colony of each isolate was inoculated to 25 ml of Nutrient broth taken in 100 ml flasks. The flasks were kept for incubation at 32°C for 24 h. Pure cultures of the isolates were subjected to RAPD analysis.

Table A : *Ralstonia solanacearum* isolates from major tomato growing areas of Karnataka

Districts	Location	Isolate number
Dharwad	UAS Dharwad	Rs-1
	Garag	Rs-2
	Sapthapur	Rs-3
Bangalore	UAS Bangalore	Rs-4
	Doddaballapur	Rs-5
Tumkur	Gubbi	Rs-6
	Hosalli	Rs-7
Gadag	Bannikoppa	Rs-8
	Lakkundi	Rs-9
Haveri	Ranebennur	Rs-10
	Chalageri	Rs-11
Belgaum	Arabhavi	Rs-12
	Gokak	Rs-13
	Kanapur	Rs-14
Mysore	Mysore	Rs-15
	Hunsur	Rs-16
Chikkballapur	Chikkballapur	Rs-17
	Chintamani	Rs-18
Shimoga	Shimoga	Rs-19
	Sagar	Rs-20
Ramanagar	Ramanagar	Rs-21
Kolar	Kolar	Rs-22
Chikkmangalur	Chikkmangalur	Rs-23
Davanagere	Davanagere	Rs-24

For RAPD analysis, the genomic DNA was isolated from the isolates following the protocol given by Sambrook and Rausell (2001). To test the quality, DNA samples were run on 0.8 per cent agarose gel in 1X TAE buffered and stained with ethidium bromide and checked for contamination by RNA (which usually runs ahead) and the DNA was evaluated by comparing it with a standard undigested DNA sample. Serial dilutions were carried out to get desired quantity of DNA for polymerase chain reaction (PCR). Thirty decamer primers under OPA, OPB and OPF series procured from M/s Bangalore Genei, Pvt. Ltd., Bangalore were tested for DNA amplification by RAPD, for producing polymorphism among the strains. Reaction mixture was prepared in 0.2 ml thin walled PCR tubes containing the following components. The total volume of each reaction mixture was 20 µl. The following reaction mixture was found to be optimum for PCR amplification. 10x assay buffer with 15 mM$MgCl_2$:2.5 µl, dNTPs mix (2.5 mM each):1.0 µl, Primer (5pM/ µl):1.0µl, Template DNA (25ng/ µl): 1.0 µl, Sterile distilled water:14.30µl,Taq DNA polymerase (3.0U/ µl):0.2 µl. DNA amplification consisted of 40 cycles of denaturation at 94°C for 1 min, annealing at 37°C for 1 min and extension at 72°C for 2 min in a Eppendorf Master cycler gradient supplied by Eppendorf Gradient, 2231, Hamburg Germany was used for cyclic amplification of DNA. The amplified products were separated on 1.5 per cent agarose gel in 1x TAE buffer at 120V and visualized on a UV transilluminator.

RESULTS AND DISCUSSION

RAPD was used to detect the variation among the isolates of *R. solanacearum* collected from different districts of Karnataka. The profile of amplicons of different primers for *R. solanacearum* isolates is given in Table 1 and Fig. 1. A total of 241 DNA bands were detected using 30 primers, total of the 139 bands were polymorphic. Out of 30 primers OPA 10, OPB 3, OPF 7 and OPF 8 showed 100 per cent polymorphism. The banding profile per primer also varied from minimum of 4 bands

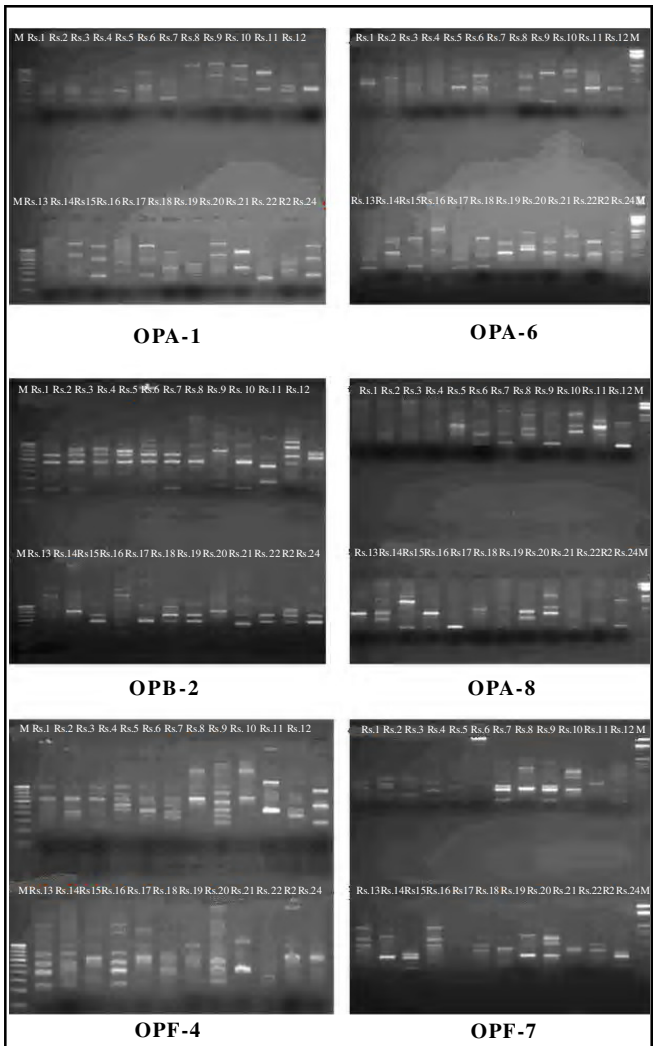

Fig. 1: RAPD banding pattern in *Ralstonia salanacearum* isolates

Table 1 : Banding profile of different primers for different isolates of *Ralstonia solanacearum*

Primers	Total bands	Polymorphic bands	% Polymorphism
OPA 1	8	7	87.5
OPA2	9	7	77.77
OPA3	4	3	75.00
OPA4	6	5	83.33
OPA5	8	5	62.50
OPA6	9	7	77.77
OPA7	7	6	85.71
OPA8	11	9	81.81
OPA9	5	4	80.00
OPA10	9	9	100.0
OPB1	6	4	66.66
OPB2	8	7	87.5
OPB3	6	6	100.0
OPB4	12	11	91.66
OPB5	6	5	83.33
OPB6	7	5	71.42
OPB7	9	5	55.55
OPB8	9	6	66.66
OPB9	8	5	62.50
OPB10	4	2	50.00
OPF1	12	12	100.0
OPF2	13	7	53.84
OPF3	16	6	37.50
OPF4	12	8	66.66
OPF5	5	4	80.00
OPF 6	6	3	50.00
OPF7	6	6	100
OPF8	8	8	100
OPF9	5	3	60.00
OPF10	7	4	57.14
Total	241	139	73.93

(OPA3) to maximum of 16 bands (OPF3). From the RAPD analysis, the results revealed that a total of 73.93 per cent polymorphism was found between the isolates, indicating that there was a high molecular variability among the isolates. Based on the simple matching coefficient a genetic similarity matrix was constructed to access the genetic relatedness among the isolates. The similarity co-efficient ranged from 0.19 to 0.61 (Table 2). The maximum genetic diversity of 0.61 per cent was observed between Hosalli (Rs-7) and Doddaballapur (Rs-9) isolates, whereas least similarity (0.19 %) was observed between Kolar (Rs-22) and Garag (Rs-2) isolates.

Information on the banding pattern for all the primers was used to determine the genetic distance between the isolates and to construct a dendrogram by using unweighted pair group arithmetic mean method (UPGMA). The dendrogram for pooled data showed seven major clusters (Fig 2). The isolates Rs-1, Rs -3, Rs-2, Rs-4, Rs-5 and Rs-6 (UAS Dharwad, Sapthapur, Garag, UAS Bangalore, Doddaballapur and Gubbi) were found in one cluster, isolates Rs-18, Rs-19, Rs-22 and Rs-23(Chintamani, Shimoga, Kolar and Chikkmangalur) formed second cluster, Rs-11 and Rs-12 of (Chalageri and Arabhavi) isolates were found in third cluster, isolates Rs-7 and Rs-9 (Hosalli and Doddaballapur) were found in fourth cluster with high genetic similarity. Rs-15, Rs-17 and Rs-24 of Mysore, Chikkaballapur and Davangere isolates were found in fifth cluster. Isolates Rs-8, Rs-14, Rs-20, Rs-13 and Rs-16 isolates of Bannikoppa, Khanapur, Shimoga, Gokak and Hunsur were found in sixth cluster. Isolates of Rs-10 and Rs-21 (Ranebennur and Ramanagar) isolates were found in seventh cluster. The genetic relation between Rs-1, Rs-3 and Rs-2 (Dharwad Garag and Sapthapur) and isolates Rs-4 and Rs-5 (UAS Bangalore and Doddaballapur) may by correlated to their geographical affiliations as they grouped into same clusters. However,

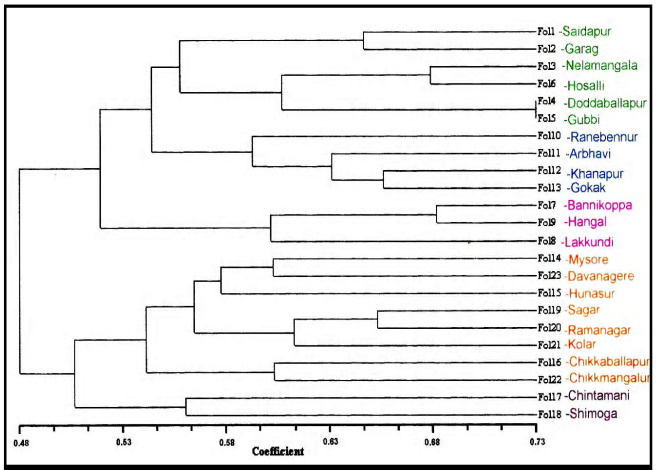

Fig. 2 : Dendrogram for twenty three isolates of *Ralstonia salanacearum* based on RAPD analysis

majority of isolates with different geographical locations were found in same cluster. It may be sumrised that the population of *Ralstonia solanacearum* in Karnataka was genetically heterogeneous and the interrelationship among the different isolates can be reliably and precisely explained by RAPD marker. There are reports on the genetic diversity among the biovars of the pathogen (Jaunet and Wang, 1997; Gunathilake *et al.,* 2004).

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RESEARCH ARTICLE

Survival of solenopsis mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) on cotton in relation to abiotic and biotic factors

■ S.C. KEDAR*, R. K. SAINI AND PALA RAM

Department of Entomology, Chaudhary Charan Singh Haryana Agricultural University, HISAR (HARYANA) INDIA

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*Corresponding author:
santoshkedar56@yahoo.com

ABSTRACT

Survival of solenopsis mealybug, *Phenacoccus solenopsis* Tinsley, on cotton was studied under field conditions, both under caged and exposed during *Kharif*, 2009 at CCS Haryana Agricultural University, Hisar. First instar nymphs (crawlers) were released on cotton plants during different months and observations on the number surviving after 10 and 20 days of release were recorded. The results indicated that as compared to exposed conditions, mealybug survival was higher under caged conditions, and the rate of decline of mealybug population was also quite slow. The ambient conditions of temperature and relative humidity did not seem to have much effect on mealybug population. However, sharp reductions in mealybug populations were observed after heavy rains. It signified the role of heavy rains in suppressing mealybug population. Among the biotic factors, the mealybug parasitoid, *Aenasius bambawalei* Hayat, was found to be active on mealybug colonies through out the observation period (i.e. July to October) and caused on an average 32.6, 42.4, 6.6 and 16 per cent reduction in the mealybug population during July, August, September and October, respectively, when observed after 20 days of release of crawlers.

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INTRODUCTION

Solenopsis mealybug, *Phenacoccus solenopsis* Tinsley, (Hemiptera: Pseudococcidae), has recently emerged as a major pest of cotton in India (Dhawan *et al*., 2007; Nagrare *et al.,* 2009). In Gujarat during 2006 *P. solenopsis* caused 50 per cent reduction of yield in highly infested cotton field (Jhala *et al.,* 2008) and in Punjab during 2007, the pest emerged in a serious proportion causing 30 to 40 per cent losses in the yield of cotton in Punjab (Dhawan *et al*., 2007). In Haryana, the pest was initially observed attacking cotton crop in Dabawali area of Sirsa district during 2006. Later on, the pest spread to several districts of the state causing serious crop losses in certain pockets during 2007 and 2008 (Saini and Ram, 2008).

Survival of mealybug is affected by various biotic and abiotic factors. However, information on these aspects is scanty. Therefore, the present investigations were carried out during *Kharif* season, 2009 at Research Farm of Department of Entomology, CCS Haryana Agricultural University, Hisar.

MATERIALS AND METHODS

The studies on survival of solenopsis mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) on cotton in relation to abiotic and biotic factors was studied during *Kharif* season, 2009 under field conditions of Research Farm of Department of Entomology at Chaudhary Charan Singh Haryana Agricultural University, Hisar (Haryana).

Freshly emerged crawlers from the ovisacs of the adult females were collected in glass vials from the laboratory

maintained culture of mealybug and released during different months on terminal leaves of 12 cotton plants @50 crawlers/ plant in the field. Six plants were caged while the remaining six were kept in exposed (uncaged) condition. The cage consisted of a cylindrical iron frame having 40 cm diameter towards the broader end and 20 cm on the narrower end with a height of 85 cm (Plate A). This frame was covered with muslin and such cages were put over the plants in the field after the first instar mealybugs (crawlers) were released on the plants. Such releases of the crawlers were made four times *i.e.* during July, August, September and October, both under caged and exposed conditions. Population count was made after 10 and 20 days after release of crawlers to determine their survival. After each observation, the cages were again put in their original position on the plants. Mean number of mealybugs present per plant was worked out. The number of mealybug mummies (*i.e.* mealybugs parasitized by *Aenasius bambawalei* Hayat) and the number of coccinellids (immature and adult stages) present on the exposed plants were also counted to determine the extent of parasitization and predation. Cumulative parasitization by *A. bambawalei* was computed.

Plate A : Cage used for field experiment

RESULTS AND DISCUSSION

Data on mean *P. solenopsis* survival, its parasitization by *Aenasius bambawalei* Hayat and number of coccinellid predators present per plant during July, August, September and October are represented by Fig. 1. (a), (b), (c) and (d), respectively.

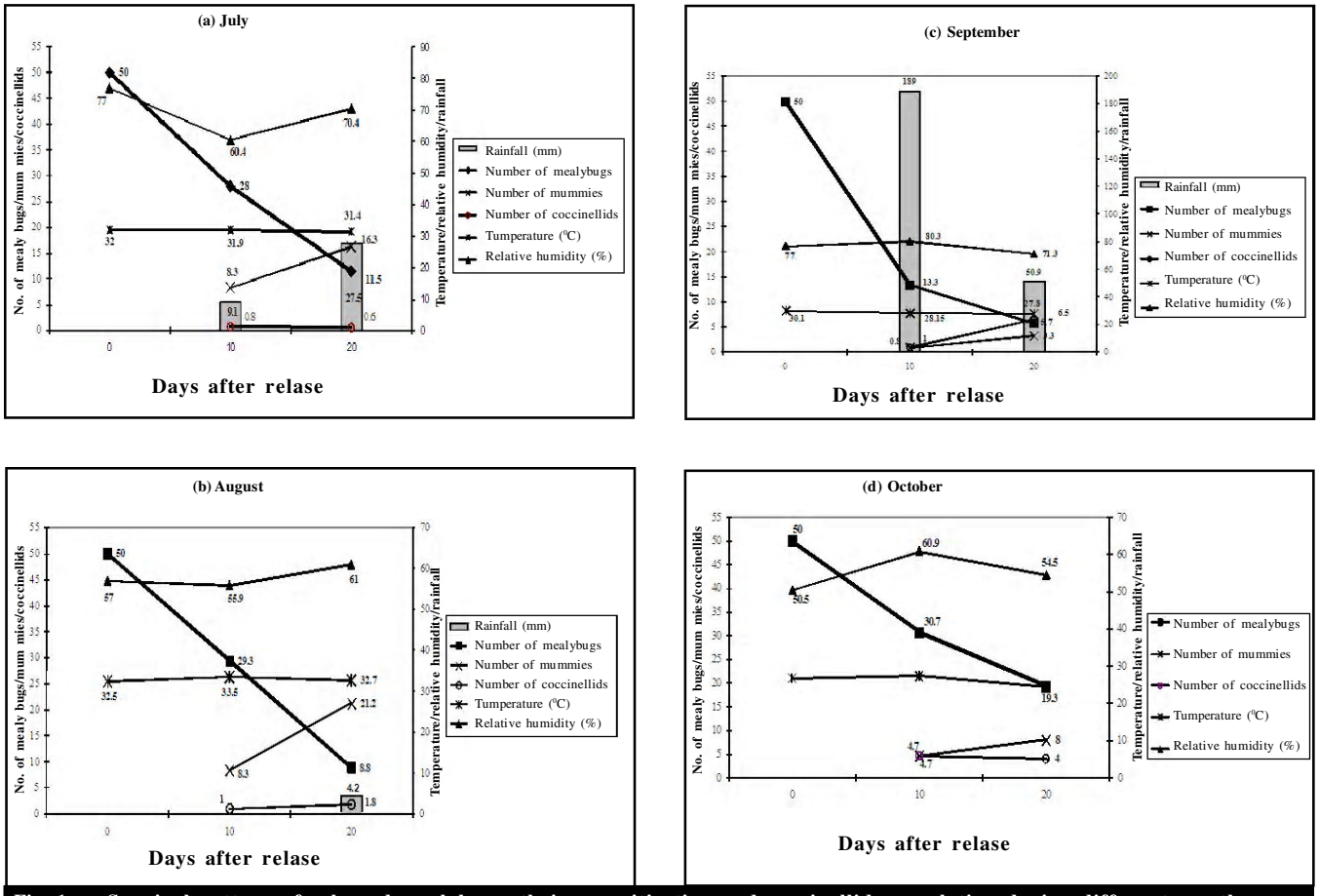

Fig. 1 : Survival pattern of released mealybugs, their parasitization and coccinellids population during different months under exposed condition

On the basis of mealybug survival during different months, it was found that there was 44, 41.4, 73.4 and 38.6 per cent reduction in mealybug population within 10 days of release of crawlers on cotton plants in the field during July, August, September and October, respectively. When the observations were recorded after 20 days of release of crawlers there was further decline in mealybug survival. The reduction in mealybug population was gradual during July and August. The ambient temperature did not seem to have any significant effect on mealybug population as there were insignificant fluctuations in mean temperature, which ranged between 31.4 and 33.5°C. No information on favourable temperature for *P. solenopsis* survival is available. However, other species of genus *Phenacoccus* have been reported to have good survival at constant temperature of 25°C under laboratory condition. Survival rate of *P. solani* was high at different constant temperature ranging from 20-30°C in the laboratory (Nakahira and Arakawa, 2006). Under laboratory condition temperature of 25° and 27°C were found to be more favourable for the development, survival and reproduction of *Maconellicoccus hirsutus* (Chong *et al*., 2008). Survival rates of nymphal instars of *P. madeirensis* when reared on chrysanthemum ranged between 92 and 100 per cent (Chong *et al*., 2003). Similarly, medium range (*i.e*. 55.9 and 77.0%) of mean relative humidity during July and August did not seem to have any significant effect on mealybug survival.

There was drastic reduction in mealybug population in September when observed after 10 days of release. This sharp reduction in population was probably due to heavy rains (189 mm) on 10th and 11th September (*i.e*. two days prior to the date of observation). This heavy down pour might have dislodged the mealybugs, particularly the young stages. Jeyakumar *et al*. (2009) also reported that intense rainfall adversely affected the mealybug population and its spread. Negative effect of heavy rains on mealybug population has been highlighted by other workers also (Dhawan *et al*., 2009; Akintola and Ande, 2009; Hanchinal *et al*., 2010; Kedar *et al.,* 2011). Mean relative humidity during the period of observation in September was relatively higher than in other months. However, its effect on mealybug population could not be established. In Pakistan, the increase in incidence of mealybug population was reported to be positively correlated with the increase in humidity (Anonymous, 2008). During October also, the decline in mealybug population was gradual as both mean temperature (24.5 to 27.5) and relative humidity (50 to 60.9 %) fell in medium range. Jeyakumar *et al.* (2009) observed that high rainfall favoured growth of entomopathogens.

The mealybug parasitoid (*A. bambawalei*) was found to be active through out the observation period (*i.e.* July to October). On uncaged plants, it caused on an average 32.6, 42.4, 6.6 and 16 per cent reduction in mealybug population during July, August, September and October, respectively, when observed after 20 days of release of crawlers. Role of *A. bambawalei* in affecting mealybug survival was prominent during August wherein it parasitized 21.2 per cent of mealybugs. Earlier *A. bambawalei* was reported to bring about 70 per cent (Ram *et al*., 2009), 20-70 per cent (Tanwar *et al*., 2008) and 20.65 per cent (Hanchinal *et al*., 2010) mortality of *P. solenopsis*.

Different coccinellid predators were recorded during July to October. Among these, maximum coccinellid population was recorded during September and October. No information is available on the extent of *P. solenopsis* mortality caused by different coccinellid predators.

It was concluded that under natural field conditions, the ambient temperature during the period of studies did not seem to have significant adverse effect on mealybug survival. Similarly, relative humidity also remained in the moderate range (*i.e*. 50.5 to 77 %) for most part of the observation period, except during September (71.3 to 80.3%) did not seem to affect mealybug survival. On the other hand, sharp reductions in mealybug population were observed after heavy rains. It signifies the role of heavy in rains suppressing mealybug population. Among the biotic factors, parasitization by *A. bambawalei* had significant role in checking mealybug population. Being general predators, the coccinellid predator seemed to play some role in regulating *P. solenopsis* population under field condition but their actual contribution could not be established. Since *P. solenopsis* population continued to decline after the release of crawlers, the important regulating factors of *P. solenopsis* population were heavy rains, parasitoids, coccinellid predators and unknown reasons. The rate of decline of mealybug population under caged condition was quite slow, which indicated that biotic factors, particularly parasitization, and direct effect of rains seemed to have significant role in regulating mealybug population under exposed condition.

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RESEARCH ARTICLE

Biological control of anthracnose of sorghum caused by *Colletotrichum graminicola*

■ YOGESH KUMAR MEENA, YOGENDRA SINGH* AND BHUPENDRA SINGH KHARAYAT

Department of Plant Pathology, College of Agriculture, G. B. Pant University of Agriculture and Technology, Pantnagar, U.S. NAGAR (UTTARAKHAND) INDIA

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*Corresponding author:
drysingh69@gmail.com

ABSTRACT

Forty isolates of *T. harzianum* and one isolate of *P. fluorescens* were tested for their antagonistic potential against *Colletotrichum graminicola*. Th-43 isolate brought maximum inhibition of radial growth (72.5%) of the test pathogen. In glass house seed biopriming experiment, maximum germination was obtained with Th-43 (84.0%), whereas maximum plant height (102.0 cm) with Th-39 and maximum reduction in disease severity (43.3 %) was observed with Th-39 and Th-43. In field trial of seed biopriming and BCA colonized compost amended soil, Th-39 recorded maximum height (234.7 cm) and stem diameter (1.8 cm) whereas maximum reduction in disease severity was obtained with Th-39 (28.1%). In seed biopriming and foliar spray trial under field conditions, maximum reduction in disease severity (45.2%) and highest green fodder yield (90 t/ha) was found in seed biopriming and three foliar spray treatment with Th-39. In foliar spray experiment carried out under field conditions, Th-39 showed maximum reduction in disease severity (34.0 %) as well as maximum green fodder yield (81.9 t/ha) where as Th-43 was also at par Th-39 in terms of green fodder yield.

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INTRODUCTION

Sorghum is attacked by a broad range of plant pathogens. Anthracnose caused by *Colletotrichum graminicola* is one of the most destructive diseases of sorghum. Reduction in grain and stover yield by 47 and 23 per cent, respectively have been reported (Pande *et al*., 2003). It occurs everywhere in the world where sorghum is grown and most of the cultivars presently grown in the country have varying degree of susceptibility to the disease. For management of this disease besides many cultural practices chemicals are also used. Chemicals are necessary at present, but are not a long term solution to crop health. Besides their non target effects and hazardous nature, many of them are now losing their effectiveness because of development of resistant strains. Moreover, application of chemicals to sorghum crop is to be avoided as the fodder is fed to the cattle. Therefore, the present investigation was carried out to evaluate the efficacy of biocontrol agents against the anthracnose pathogen.

MATERIALS AND METHODS

Source of biocontrol agents :

Forty isolates of *Trichoderma harzianum* and one of *Pseudomonas fluorescens* were used throughout the course of investigation. For *in vitro* studies and glasshouse experiments, the various *T. harzianum* isolates used were Th - 1to Th-23, Th-25 to Th-34, Th-36 to Th-40,Th-42 to Th-45 whereas *P. fluorescens* isolate was Psf 28. For field evaluation, the formulations of Th-43, 39 and PSF -28 were used. These bioagents were obtained from Biocontrol Laboratory of Department of Plant Pathology, G.B. Pant

University of Agriculture and Technology, Pantnagar.

***In vitro* testing of antagonism between *T. harzianum* isolates and *C. graminicola* by bangle method :**

A 5 mm disc was cut from the periphery of actively growing culture (3 to 5 days old) of the test fungus (on oat meal agar medium) with the help of sterilized cork borer and was centrally inoculated in Petri plates (9 cm diameter) seeded with oat meal agar (approx. 20 ml/ plate). A flame sterilized glass bangle (6cm diameter) was dipped in conidial suspension of different *Trichoderma harzianum* isolates in 2 per cent autoclaved sterilized gelatin solution and transferred carefully to Petri plates with the help of sterilized forceps. After dipping the bangle in spore suspension, it was held for some time to allow excess of suspension to trickle down before transferring to the Petri plates. In case of control bangles were dipped in 2 per cent gelatin solution only. The test pathogen being relatively slow growing was inoculated 48 hours prior to *Trichoderma harzianum*. Three replications were used for each treatment. All the plates were incubated at 28±1^{0}C. Radius of the fungal pathogen was recorded 48 hours after inoculation. Per cent inhibition of growth and time taken by *Trichoderma* to completely overgrow the fungal pathogen were taken into account as criteria to compare their antagonistic potential. The percent inhibition of radial growth was calculated with following formula :

$$\text{Per cent inhibition of radial growth} = \frac{\text{Radial growth in check} - \text{radial growth in treatmens}}{\text{Radial growth in check}} \text{x100}$$

Glass house experiment :

***Seed biopriming experiment* :**

Pots of 30 cm. size were filled with sterilized soil and then the bioprimed seeds were sown in these pots. Biocontrol agents were used @ 10 g spores/cell (2 ×10^9 cfu/ml) / kg of seeds for each treatment. Each isolate was mixed with 50 ml of 2 per cent gum arabic solution and then seeds were incubated at 28±1^{0}C for 24 hours before sowing to allow covering of seed surface with bioagents. The gum arabic solution acts as a sticking material and keeps the bioagents glued to the seed surface. The observations on germination percentage, height of plants and disease severity were recorded. Each treatment was replicated thrice. Congenial growth conditions were provided to the experimental plants. The inoculation of the plants with the pathogen was done when they were 1 month old. The observation on plant height, stem diameter and disease severity were recorded after 60 days of sowing while germination was recorded after 15 days of sowing.

Field trials :

Field experiments were conducted during the kharif season of 2007 at Livestock Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar to evaluate the efficacy of selected bioagents in controlling anthracnose of sorghum.

Seed biopriming :

Biopriming was done 24 hours before sowing by treating the seeds with talc based formulation of biocontrol agents (Th-39, Th-43 and Psf-28) @ 10g spores/cells (2×10^9 cfu/ml) / kg seeds in 2% gum arabic solution. Thirty days old plants were artificially inoculated by spraying the spore suspension (5×10^4 spores/ml) of test pathogen on the sorghum plants. Bioprimed seeds were used for sowing in two separate experiments; one in which soil was amended with BCA colonized compost while other was without any amendment. Observations on disease severity, plant height and stem diameter were recorded 60 days after sowing whereas green fodder yield was recorded after harvesting.

Seed biopriming and foliar spray :

Seeds were bioprimed in aforementioned manner with (Th-43 Th-39) and (Psf-28). Thirty days old plants in the field were artificially inoculated by spraying the spore suspension of the pathogen containing 5×10^4 spores/ml. The inoculum was sprayed between 6-7 pm as night temperature and humidity were conducive for infection. Three sets of experiment were conducted *viz.,* first set: bioprimed seed and one spray; second set-bioprimed and two spray; third set: bioprimed seed and three spray. In all the sets, first spray of the biocontrol agent @ 10 g spores/cells (2 ×10^9 cfu /ml) /lit. of water was given before three days of inoculum spray. Second and third sprays were given at 10 days interval.

Foliar spray :

Talc based formulations of Th-43, 39 and Psf-28 were sprayed as in seed biopriming and foliar spray experiment to test their efficacy against the pathogen. Trials were laid out in a Randomized Block Design (RBD) with three replications. Observations on disease severity were recorded in 1-5 scale proposed by All India Coordinated Sorghum Improvement Project after 60 days of sowing as follows: 1 = No symptoms (Highly resistant), 2= upto 10% intensity (Resistant), 3=11-25% intensity (Moderately resistant), 4=26-50% intensity (Susceptible), 5=above 50% intensity (Highly susceptible). Following formula was used to calculate the percent disease severity :

$$\text{Per cent disease severity (S)} = \frac{\text{Sum of numerical rating}}{\text{Total no. of samples x maximum rating grade}} \text{x100}$$

RESULTS AND DISCUSSION

The results of the present study as well as relevant discussions have been presented under following sub heads:

***In vitro* testing of antagonism between *Trichoderma* isolates and *C. graminicola* using bangle method :**

Antagonistic potential of 40 isolates of *T. harzianum* and 1 isolate of *P. fluorescens* (Psf-28) was evaluated against the pathogen, *C. graminicola* by bangle method (Table 1). Th-43 performed best which gave 72.5% inhibition of radial growth followed by Th-39 (72.3%), Th-36 (64.2%), Th-37 (63.4%), Th-4 (62.2%), Psf-28 (61.8%) and Th-22 (61.7%) while least inhibition (7.7%) was obtained with Th-44. All *T. harzianum* isolates tested for antagonism *in vitro* were found to be effective to varying extents. In fact the difference in per cent inhibition of radial growth indicates, the difference in their antagonistic potential for the test pathogen. In present results, a clear cut zone of inhibition was observed with Th-3, 4, 9, 13, 22, 32, 37, 39, 38, and 43 isolates tested against the pathogen. This may be due to mechanism of antibiosis by the antagonists. *Trichoderma* spp. inhibiting the growth of pathogens by the mechanism of antibiosis has been reported earlier. (Bangari and Singh, 2011).

Table 1: Per cent inhibition of radial growth of *C. graminicola* by different isolates of *T. harzianum* and *P. fluorescens* under *in vitro* condition by Bangle method after 7 days

Treatments	Average radial growth of fungus (cm)	Inhibition of radial growth (%)
Th-1	2.4	59.4 (50.4)
Th-2	2.8	51.8 (46.0)
Th-3	2.3	61.2 (51.0)
Th-4	2.2	62.2 (52.0)
Th-5	2.4	58.5 (49.9)
Th-6	2.5	56.9 (48.9)
Th-7	4.7	21.3 (27.1)
Th-8	2.6	55.7 (48.3)
Th-9	4.0	32.1 (34.5)
Th-11	4.5	24.0 (29.3)
Th-12	2.6	56.2 (48.6)
Th-13	4.8	18.4 (25.4)
Th-14	5.0	16.3 (23.8)
Th-15	4.6	22.1 (28.0)
Th-17	4.1	30.1 (33.2)
Th-18	2.7	54.7 (47.7)
Th-19	5.5	8.0 (16.5)
Th-20	5.4	9.3 (17.7)
Th-21	5.6	5.9 (14.1)
Th-22	2.2	61.6 (51.7)
Th-23	4.4	26.2 (30.8)
Th-25	2.3	60.6 (51.1)
Th-26	4.5	23.6 (29.0)
Th-27	2.6	55.9 (48.4)
Th-28	4.2	29.7 (33.0)
Th-29	4.4	25.7 (30.4)
Th-30	5.0	16.4 (23.8)
Th-31	2.4	59.5 (50.4)
Th-32	2.3	61.0 (51.3)
Th-33	5.3	11.1 (19.5)
Th-34	5.1	14.4 (22.3)
Th-36	2.1	64.2 (53.2)
Th-37	2.1	63.7 (52.9)
Th-38	2.3	61.0 (51.3)
Th-39	1.6	72.3 (58.2)
Th-40	5.4	9.7 (18.1)
Th-42	5.4	8.4 (16.8)
Th-43	1.6	72.4 (58.4)
Th-44	5.2	7.7 (16.1)
Th-45	4.8	19.5 (26.2)
Psf-28	3.5	61.8 (51.3)
Control	9.0	--
C.D. at 5 %	0.20	1.15

*Figures in parentheses are angular transformed values.

Glass house experiments :

***Seed biopriming experiment* :**

As bio-control agents are known to promote growth and induce the resistance in plants, biopriming of seeds was done with forty different *T. harzianum* isolates and one *P. fluorescens* isolates for 24 hours and observations on germination, height of the plant and disease severity were recorded (Table 2). Among all treatments Th-1, 2, 3, 4, 9, 21, 22, 27, 28, 29, 32, 34, 36, 38, 39, 40, 43 and Psf-28 showed significant increase in germination over control. Maximum germination was observed with Th-43 (84%) followed by Th-36 (83.7%) and Th-39 (83.3%). Plant height was observed maximum in Th-39 (102cm) treated seeds followed by Th-43 (100cm), Th-36 (98.7cm) and Psf-28 (97.7cm), while in control plant height was 89.0 cm. While studying the effects of different isolates of *Trichoderma* on host plants, Chet (1987) and Kleifeld and Chet (1992) obtained similar growth promotion results. Maximum reduction in disease severity was obtained with Th-39 and Th-43 (43.3%) followed by Th-32 (41.6%), Th-11 (39.1%), Th-36 (38.3%), Th-45 (37.5) and Psf-28 (33.8%). The present findings are in consonance with those reported by Nzojiyobiri *et al.* (2003); Chen *et al.* (2005) and, Vidhyasekaran and Muthamilan (1995). Mechanism of disease reduction is probably induced systemic resistance because the pathogen is not in direct contact with the bio-control agent; the resistance thus exerted by the plant seems to have originated systemically.

Field trials :

***Bioprimed seeds in plots amended with BCA colonized compost* :**

Seeds of susceptible sorghum variety PC-4 which were bioprimed for 24 hours with different biocontrol agents were

Table 2: Effect of seed biopriming on seed germination, plant height and disease severity under glass house condition

Treatment	Germination (%)	Plant height (cm)	Disease severity (%)	Decrease in disease severity (%)
Th-1	78.0 (62.0)	92.5	34.3 (35.9)	14.2
Th-2	80.3 (63.7)	92.6	29.0 (32.6)	27.5
Th-3	76.7 (61.1)	89.8	34.3 (35.9)	14.2
Th-4	75.7 (60.4)	95.5	34.7 (36.1)	13.4
Th-5	67.7 (55.4)	89.8	34.7 (36.1)	13.3
Th-6	69.3 (56.4)	91.5	27.0 (31.3)	32.5
Th-7	67.7 (55.4)	88.5	34.0 (35.6)	15.0
Th-8	66.7 (54.8)	90.4	31.3 (34.0)	21.7
Th-9	74.3 (59.6)	92.1	26.0 (30.6)	35.0
Th-11	63.3 (52.7)	89.5	24.3 (29.6)	39.2
Th-12	68.3 (55.8)	92.5	29.3 (32.8)	26.7
Th-13	63.7 (52.9)	93.5	31.3 (34.0)	21.7
Th-14	65.7 (54.1)	90.9	32.0 (34.4)	20.0
Th-15	67.0 (54.9)	91.4	29.0 (32.6)	27.5
Th-17	68.0 (55.6)	92.2	26.3 (30.9)	34.2
Th-18	65.6 (54.1)	93.9	26.0 (30.7)	35.0
Th-19	69.0 (56.2)	94.6	30.0 (33.2)	25.0
Th-20	70.0 (56.8)	94.3	34.7 (36.1)	13.4
Th-21	71.0 (57.4)	92.9	35.3 (36.7)	11.7
Th-22	70.7 (57.2)	96.6	35.3 (36.5)	11.7
Th-23	73.0 (58.7)	93.6	33.0 (35.1)	17.5
Th-25	68.0 (55.6)	90.7	32.0 (34.4)	20.0
Th-26	69.3 (56.4)	91.0	32.3 (34.7)	19.2
Th-27	71.0 (57.4)	92.3	31.7 (34.2)	20.9
Th-28	72.7 (58.5)	92.7	31.7 (34.2)	20.9
Th-29	72.7 (58.5)	92.6	32.7 (34.9)	18.4
Th-30	68.3 (55.8)	94.0	33.7 (35.5)	15.9
Th-31	68.7 (55.9)	91.0	32.0 (34.4)	20.0
Th-32	80.7 (63.9)	98.0	23.3 (28.9)	41.7
Th-33	70.0 (57.2)	91.5	33.3 (35.3)	16.7
Th-34	72.3 (58.3)	96.5	31.3 (34.0)	21.7
Th-36	83.7 (66.2)	98.7	24.7 (29.8)	38.4
Th-37	68.7 (55.9)	92.0	35.0 (36.3)	12.5
Th-38	82.7 (65.5)	95.2	24.7 (29.8)	38.4
Th-39	83.3 (66.0)	102.0	22.7 (28.4)	43.4
Th-40	74.7 (59.8)	93.5	31.7 (34.0)	30.9
Th-42	69.3 (56.4)	92.0	32.7 (34.9)	18.4
Th-43	84.0 (66.5)	100.0	22.7 (28.4)	43.4
Th-44	70.0 (56.8)	92.5	31.0 (33.8)	22.5
Th-45	70.0 (56.8)	92.2	25.0 (29.9)	37.5
Psf-28	76.3 (60.9)	97.7	26.5 (41.8)	33.8
Control	68.4 (55.8)	89.0	44.0 (41.6)	--
C.D. at 5 %	2.3	1.2	1.4	----

*Figures in parentheses are angular transformed values

used for sowing in this experiment. The observations on plant height, stem diameter and disease severity were recorded. Results presented in Table 3 indicate that all the treatments recorded significant increase in height over control. A maximum plant height of 234.7 cm was observed in Th-39 treated seeds followed by Th-43 (234.3 cm) and Psf-28 (230.8 cm). All the treatments increased the stem diameter significantly over control except Psf-28. Maximum stem diameter was observed in Th-39 (1.8 cm). All the treatments were found to be significantly superior in reducing disease severity over control. A maximum reduction in disease severity was observed in Th-39 (28.1%). Maximum increase in green fodder yield was observed with Th-39 (28.1%) followed by Th-43 (27.2%).

Seed biopriming and foliar spray :

Effect of seed biopriming and foliar spray with bio-control agents on plant growth and disease severity of anthracnose was evaluated. Results presented in Table 4 indicate a significant increase in plant height, stem diameter and reduction in disease severity in all treatments. Increase in plant height, stem diameter, green fodder yield and reduction in disease severity were observed as number of spray increased. Maximum reduction in disease severity (45.3%) and highest green fodder yield (90 t/ha) was found in seed biopriming and 3 foliar spray treatment with Th-39. Present findings are in consonance with those reported by Julien (2006) on effect of spray with biological control agent *P. fluorescens* in phylloplane upon plant growth. Similar findings have been reported by Singh and Singh (2008) while studying the effect of seed biopriming and spraying *T. harzianum* isolates in reducing disease severity and increasing plant growth and yield of sorghum. Th-39 was superior in increasing in plant height (31%) and green fodder yield (17%) over control in a foliar spray experiments. Th-43 resulted in reduced disease severity over control in treatments with seed biopriming, compost colonized by biocontrol agents and seed biopriming

Table 3: Effect of seed biopriming and BCA colonized compost on plant growth and disease severity

Treatments	Plant height (cm)	Stem diameter(cm)	Disease severity (%)	Decrease in disease severity (%)	Green fodder yield (q/ha)	Per cent increase in green fodder yield
Th-39	234.7	1.8	39.0 (38.6)	28.1	82.6	28.1
Th-43	234.3	1.7	39.8 (39.1)	26.5	82.0	27.2
Psf-28	230.8	1.6	42.1 (40.4)	22.4	74.7	15.9
Contaf	225.9	1.5	38.8 (38.5)	28.4	74.0	14.7
Control	220.2	1.5	54.2 (47.4)	--	64.5	--
C.D. at 5 %	0.8	1.0	0.2		0.7	

*Figures in parentheses are angular transformed values

Table 4: Effect of seed biopriming and foliar spray on plant growth and disease severity

Treatments	No. of spray	Plant height (cm)	Stem diameter (cm)	Disease severity (%)	Decrease in disease severity (%)	Green fodder yield (q/ha)	Per cent increase in green fodder yield
	1	232.3	1.7	36.5 (37.1)	32.5	77.7	20.5
Th-39	2	236.6	1.8	30.5 (33.5)	43.9	82.0	27.2
	3	237.6	1.9	29.7 (33.0)	45.3	90.0	39.6
	1	232.5	1.7	39.4 (38.9)	27.5	82.0	27.2
Th-43	2	235.2	1.8	35.7 (36.7)	37.3	83.7	29.8
	3	236.4	1.8	34.0 (35.7)	39.2	85.7	32.9
	1	229.9	1.5	41.1 (39.9)	24.2	81.3	26.7
Psf-28	2	233.5	1.6	37.8 (37.9)	30.3	86.3	33.9
	3	235.1	1.6	37.2 (37.6)	31.4	88.7	37.5
	1	226.1	1.5	35.9 (36.8)	33.9	74.0	14.7
Contaf	2	228.2	1.6	32.9 (35.0)	39.3	75.3	16.7
	3	232.8	1.6	30.9 (33.8)	42.9	76.0	17.8
Control		220.2	1.5	54.3 (47.4)	--	64.5	--
C.D. at 5 %		0.9	0.5	0.4		8.5	

*Figures in parentheses are angular transformed values

Table 5: Effect of foliar spray of biocontrol agents on plant growth and disease severity

Treatments	No. of spray	Plant height (cm)	Stem diameter (cm)	Disease severity (%)	Decrease in disease severity (%)	Green fodder yeld (q/ha)	Per cent increase in geen fodder yield
	1	230.3	1.6	40.0 (39.3)	26.2	80.7	25.1
Th-39	2	232.8	1.7	36.4 (37.1)	32.9	81.8	28.4
	3	233.1	1.7	35.6 (36.7)	34.3	81.9	27.1
	1	230.3	1.6	40.1 (39.3)	26.2	80.9	25.1
Th-43	2	232.4	1.7	36.3 (37.1)	33.0	81.5	26.4
	3	232.9	1.7	35.8 (36.7)	34.0	81.9	27.1
	1	225.7	1.5	43.8 (41.4)	19.3	73.6	14.2
Psf-28	2	227.3	1.6	40.8 (39.7)	24.8	74.7	15.8
	3	227.4	1.6	40.7 (39.7)	24.9	74.9	16.1
	1	225.1	1.5	40.0 (39.2)	26.3	74.0	14.7
Contaf	2	227.2	1.6	32.1 (34.5)	40.9	74.9	16.1
	3	237.8	1.6	31.6 (34.1)	41.8	75.9	17.7
Control		220.2	1.5	54.3 (47.4)	--	64.5	--
C.D. at 5 %		0.7	0.6	1.8		0.7	

*Figures in parentheses are angular transformed values

and foliar spray by 20, 22 and 21per cent, respectively.

Foliar spray :

Effect of foliar spray of Th-43, Th-39 and Psf-28 on plant growth and disease severity of anthracnose was determined. Results presented in Table 5 indicate a significant increase in plant height in all treatments over control. Stem diameter was observed to be significantly superior in all the treatments over control. A maximum (34.0%) reduction in disease severity was observed by 3 spraying with Th-39. However, Th-43 was at par with Th-39 in reducing disease severity. Maximum yield was obtained with Th-43 and Th-39 (81.9t/ha) with 3 spray treatment. Similar observations on reduction of disease severity were obtained by Sati (2005) while working with *T. harzianum* and *P. fluorescens* foliar spray against *C. graminicola,* the anthracnose pathogen of sorghum.

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RESEARCH ARTICLE

Reaction of sunflower hybrids to powdery mildew caused by *Erysiphe cichoracerum* DC.

■ K. KARUNA*, NAGARAJU, Y. G., SHADAKSHARI, K. S. JAGADISH AND K. N.GEETHA

AICRP on Sunflower, Zonal Agricultural Research Station, University of Agricultural Sciences, BENGALURU (KARNATAKA) INDIA

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*Corresponding author:

ABSTRACT

Five sunflower hybrids KBSH -1, KBSH -41, KBSH -42, KBSH -44 and KBSH -53 were assessed under glasshouse conditions for resistance to a field population of powdery mildew fungus *Erysiphe cichoracearum* DC. Hybrid KBSH 53 recorded least powdery mildew severity of 4.2 per cent as compared with other hybrids and was resistant to powdery mildew. The highest disease severity (61 %) was recorded in hybrid KBSH-44 which was highly susceptible to powdery mildew.

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INTRODUCTION

Erysiphe cichoracearum DC. is a widely distributed pathogen of cultivated annual sunflower (*Helianthus annuus* L.). Infection of sunflower by *E. cichoracearum* causes early senesence during the flowering stage and upto 15 per cent stunting and 81 per cent reduction in yield in the greenhouse. Powdery mildew may also cause economically significant reduction in sunflower production in tropical areas. Cultivars of sunflower are known to differ in their reaction to the powdery mildew fungus (Zimmer and Hoes, 1978). The only known source of resistance lies in wild *Helianthus* species (Jan and Chandler, 1985). The annual species of *Helianthus debelis* sub.sp. *sylvestris*, *H. praecox* sub.sp. *praecox* and *H. bolanderi* and the perennial species, *H. californicus*, *H. ciliaris*, *H. decapetalus*, *H. lacinatus* and *H. rigidus* were reported to be tolerant to powdery mildew under green house and natural conditions (Saliman *et al*., 1982).

Powdery mildew affects most of the commercial varieties under present cultivation and it has been reported from different parts of the world. The powdery mildew of sunflower was first reported from US in 1928 (Anonymous, 1928). In India, the disease was first reported from Bombay province (Patel *et al*., 1949), later from Rajasthan (Prasada *et al*., 1968), West Bengal (Goswami and Dasgupta, 1981) and Punjab (Bains *et al*., 1996) causing considerable reduction in yield. The disease manifests as minute discoloured speck on leaves from which powdery mass radiates in all directions. All the aerial parts of the host are covered with white powdery mass containing mycelia and conidia of the fungus (Plate A).

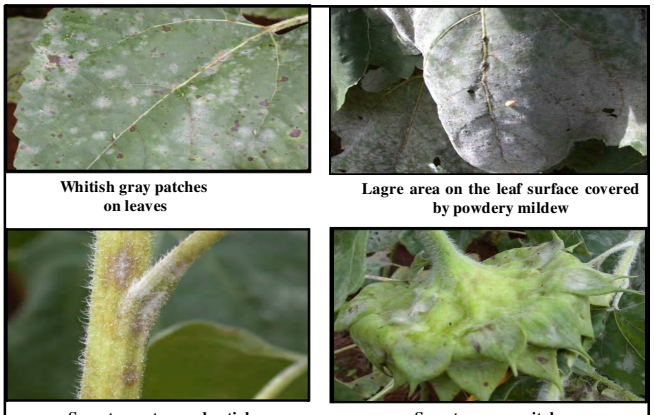

Plate A : Different stages of symptoms produced by Erysiphe cichoracearum on sunflower

Powdery mildew was rarely observed in Karnataka before 2006. Severe foliar (80%) infections by powdery mildew was observed during 2006 at Challakere, Chitradurga district in Karnataka (Anonymous, 2007). Since then the disease is being regularly seen in different parts of Karnataka in moderate to severe form. The loss due to powdery mildew is proportionate to the disease severity and varies considerably depending on the stage of the plant growth at which disease occurs. High inoculum in the field coinciding with favourable environmental conditions leads to early infections causing severe loss. In this paper the reaction of sunflower hybrids to infection by *Erysiphe cichoracearum* is discussed in the light of earlier reports .

MATERIALS AND METHODS

The present investigation was undertaken during 2010 at Zonal Agricultural Research Station, University of Agricultural Sciences, GKVK, Bengaluru. Reaction of sunflower genotypes *viz.*, KBSH -1, KBSH -41, KBSH -42, KBSH -44 and KBSH -53 to *E.cichoracearum* causing powdery mildew was carried out to know their resistance or susceptibility.

Maintenance of inoculum :

The inoculum of *E .cichoracearum* used in this study for artificial innoculations was obtained from naturally infected plants in the field at Zonal Agricultural Research Station , GKVK, Bengaluru. Conidia from clear, separate and isolated colonies were picked up through the bristles of a brush and dusted onto KBSH 44 plants raised in glasshouse which is highly susceptible to powdery mildew. Isolated colonies developing on these plants were further transferred to large number of KBSH 44 plants and a pure culture originating from a single, well developed, isolated colony was established. The culture, thereafter, was maintained in the glass house to avoid contamination and to provide a constant source of fresh conidia. The culture was transferred to new plants by dusting the conidia on the leaf surface using camel hair brush as and when required.

Screening of hybrids:

The hybrids to be screened under *in vitro* conditions were raised in earthern pots when the seedlings were 30 days old. These plants were randomly placed among the plants on which culture was maintained and were innoculated at or after the three to five leaf stage by dusting conidia onto the leaves of plants three to four times. Disease severity was recorded six weeks after the last inoculation was done. The powdery mildew severity was recorded by recording the per cent leaf area covered by the disease, through visual observation using a rating scale of 0-9 scale (Mayee and Datar,1986) on five marked plants of each hybrid. The epiphytotic was recorded by selecting three leaves per plant on five plants from each hybrid on a random basis. The genotypes were further grouped based on reaction type as given by Khare and Lakpale (1997).

Reaction	Leaf area covered
Immune (I)	No symptom of powdery mildew on leaves.
Highly resistance (HR)	Small scattered powdery mildew specks covering 1 % or less leaf area.
Resistance (R)	Small powdery lesions covering 1-10 % of leaf area.
Moderately resistant/ Moderately susceptible (MR/MS)	Powdery lesions enlarged covering 11-25% of leaf area.
Susceptible (S)	Powdery lesions coalesce to form big patches covering 26-50% of leaf area.
Highly susceptible (HS)	Big powdery natches covering: 51% or more of leaf area and defoliation occur

RESULTS AND DISCUSSION

The culture was sent to The Herbarium Cryptogame Indiae Orientalis (HCIO), Division of Plant Pathology, Indian Agricultural Research Institute, New Delhi, India and was identified as the oidium state of *E. cichoracearum* with the accession /identification number HCIO 50056.

Reactions of hybrids in the glass house experiments is presented on Table1. Hybrid KBSH 53 recorded least powdery mildew severity of 4.2 per cent compared with other hybrids and was recorded as resistant to powdery mildew.

Table 1 : Screening of sunflower hybrids against powdery mildew of sunflower

Hybrid	Disease severity (%) Greenhouse	Reaction
KBSH 1	43	Susceptible
KBSH 41	45	Susceptible
KBSH 42	47	Susceptible
KBSH 44	61	Highly susceptible
KBSH 53	4.2	Resistant

The highest disease severity (61 %) was recorded in hybrid KBSH-44 which was recorded as highly susceptible to powdery mildew. Whereas, other hybrids namely, KBSH-1, KBSH- 41 and KBSH-42 showed disease severity ranging from 43 to 47 per cent and were found susceptible to powdery mildew. While, KBSH 53 was recorded as resistant and KBSH 44 as highly susceptible genotypes .

Several workers had previously reported about the resistance sources against powdery mildew of sunflower.

Jan and Chandler (1988) reported that PM1 derived from the *H. debelis* parental group was resistant to *E. cichoracearum* in USA. It contained the partially dominant powdery mildew resistance gene(s) of *H. debilis* at a frequency of about 50 per cent. A recessive genetic male-sterility gene from P 21 was also present upto 50 per cent. It was believed to be the first sunflower genotype highly resistant to *E. cichoracearum*. Eva (2002) opined that the response of sunflower plants to infection by *E. cichoracearum* f.sp. *helianthi* varied with genotype, phenological stage at which infection began, affected organ and climatic conditions. He also observed that resistance to infection was high before flowering and low during flowering up to physiological ripening. The yields of the hybrids were significantly affected by the disease incidence and climatic conditions. Hybrids such as Splendor, Select and Performer recorded higher yields than the control, whereas Rapid and Super with lower yields. The use of glasshouse tests to identify resistance to the powdery mildew pathogen in different lines will result in a significant savings in time, labour and field space.

The different reactions of the five hybrids to *E. cichoracearum* suggests that the response to infection by *E. cichoracearum* may be characteristic of the hybrid . The screening of the hybrids has resulted in the ifentification of KBSH 53 as resistant to powdery mildew.

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RESEARCH ARTICLE

Field efficacy of different modules prepared by using combination of biopesticides and synthetic insecticides against okra shoot and fruit borer

■ N.T. CHORAGE, V.S. DESAI* AND S.C. RITE

Department of Agriculture Entomology, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, RATNAGIRI (M.S.) INDIA

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*Corresponding author:
vvpp_s@yahoo.co.in

ABSTRACT

The yield data on marketable fruits recorded in various treatments revealed that highest yield of 36.56 q/ha was recorded in module M_9 (cypermethrin 10 EC 0.005 per cent followed by NSKE 5 per cent followed by custard apple leaf extract 10 ml aqueous solution L^{-1}) followed by module M_5 (deltamethrin 0.09 per cent, followed by Neemazal 4ml L^{-1} followed by soapnut 10 ml aqueous solution L^{-1}) (36.29 q/ha), followed by module M_8 (Profenofos 50 EC 0.05 %, followed by NSKE 5 % then garlic and chilli extracts 10 ml aqueous solution $^{-1}$) (36.11 q/ha), followed by M_4 (endosulfan 35 EC (0.06%) followed by *B thuringiensis* var. *kurstaki* @ 1.5 g L^{-1} followed by custard apple leaf extract 10 ml aqueous solution L^{-1} (35.72 q/ha) and M_3 (endosulfan 35 EC (0.06%) followed by *B thuringiensis* var. *kurstaki* @ 1.5 g L^{-1} followed by Serni leaf extract 10 ml aqueous solution L^{-1}) (35.06 q/ha) which were at par with module M_9.

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INTRODUCTION

Okra [*Abelmoschus esculentus* (Linn.) Moench] is one of the most important vegetables grown in tropical and sub-tropical parts of the world. It belongs to the family Malvaceae. Okra is subjected to the attack of as many as 72 insects and non-insect pests in the country (Rawat and Saha, 1973).The okra shoot and fruit borer caterpillar initially bores the growing shoot and later on the buds and fruits. It feeds on internal contents. In case of severe infestation, complete fruit is deshaped, hollowed and filled with humus like excreta. The pest directly affects green fruit yield as well as seed yield on maturity. It inflicts qualitative and quantitative losses in seed yield. Kadam (1993) reported that, shoot and fruit borer alone causes 66.28, 46.45 and 69.04 per cent loss in fruit yield in crops sown in summer, *Kharif* and *Rabi* seasons, respectively with an average loss of 60.69 per cent in absence of plant protection umbrella.

Application of insecticides is generally practiced by the farmers for higher gains, but its injudicious use has created many problems. Sole reliance on chemical control leads to problems of pesticide resistance, resurgence of minor pests, pesticide residues, destruction of beneficial fauna and environmental pollution. Under such circumstances, the use of botanical insecticides in pest management is considered as ecologically viable proposition which overcome the above mentioned problems (Adilakshmi *et al.,* 2008). Though some primary work has been done on recording the pests infesting okra in Konkan region and their control by various ways, the work on the use of ecofriendly methods has not been properly studied so far. Also with the increasing emphasis from the environmentalists to apprehend the use of chemical pesticides, the present study was undertaken.

MATERIALS AND METHODS

The experiment was conducted on Horticulture farm, Department of Horticulture, College of Agriculture, Dapoli in Randomized Block Design with three replications and ten treatments. Arka Anamika variety was used for the experiment. The treatment details were as follows :

Method of recording observations :

The pre-count observations were recorded one day prior to application of treatments and post-treatment observations were recorded at 3, 7, and 14 days after each spray.

Initially the observations were recorded on shoot infestation. Later, the observations were recorded both on shoots as well as flower buds and fruits. The per cent infestation was worked out on the basis of healthy and infested fruits on number basis. The weight of healthy and infested fruits from ten randomly selected plants was recorded at each observation and data thus obtained were converted into per cent infested fruit and analyzed statistically. The per cent infestation of okra shoot and fruit borer recorded at 3, 7 and 14 days of each spray was pooled and presented as relative efficacy of respective spray. The yield obtained from the blocks of various treatments was recorded separately after categorizing it into damaged and healthy and analyzed statistically.

RESULTS AND DISCUSSION

The relative efficacy of predefined modules consisting of bio pesticides, botanicals and chemical pesticides were evaluated under the field conditions for the management of shoot and fruit borer, *E.vittella* infesting okra during *Rabi* season of 2009-2010 are presented below :

Relative efficacy of different modules against okra shoot and fruit borer, *E.vittella* on number basis :

The study on overall efficacy of modules tested in present investigation is given in Table 1.

The cumulative effect of all the sprays indicated that the module M_4 composed of endosulfan 35 EC (0.06%) followed by *B. thuringiensis* var. *kurstaki* @ 1.5 g L^{-1} followed by Maharukh leaves extract 10 ml aqueous solution L^{-1} recorded lowest fruit infestation of 15.89 per cent. However, the module M_3 (endosulfan 35 EC 0.06 per cent followed by *B. thuringiensis* var. *kurstaki* @ 1.5 g L^{-1} followed by Serni leaf extract 10 ml aqueous solution L^{-1}), module M_9 (cypermethrin 10 EC 0.005 per cent followed by NSKE 5 per cent followed by custard apple leaf extract 10 ml aqueous solution L^{-1}) , module M_5 (deltamethrin 0.09 per cent, followed by Neemazal 4 ml L^{-1} followed by soapnut 10 ml aqueous solution L^{-1}), module M_8 (Profenofos 50 EC 0.05 per cent, followed by NSKE 5 per cent then garlic and chilli extract 10 ml aqueous solution L^{-1}) composed of alternate spray of chemical and bio pesticides had also recorded nearly low fruit infestation (16.11, 16.92, 16.38 and 17.02 per cent, respectively) comparable with module M_4.

Relative efficacy of different modules against okra shoot and fruit borer, *E. vittella* on weight basis :

The study on overall efficacy of modules tested in present investigation is given in Table 2. The cumulative effect of all the sprays indicated that the module M_9 (cypermethrin 10 EC 0.005 per cent followed by NSKE 5 per cent followed by custard apple leaf extract 10 ml aqueous solution L^{-1}) , module M_8 (Profenofos 50 EC 0.05 %, followed by NSKE 5 % then garlic and chilli extract @ 10 ml aqueous solution L^{-1}), module M_5 (deltamethrin 0.09 per cent followed by Neemazal @4ml L^{-1} followed by Soapnut 10 ml aqueous solution L^{-1}), M_4 composed of endosulfan 35 EC (0.06%) followed by *B thuringiensis* var. *kurstaki* @ 1.5 g L^{-1} followed by custard apple leaf extract 10 ml aqueous solution L^{-1} and M_3 (endosulfan 35 EC (0.06%) followed by *B thuringiensis* var. *kurstaki* @ 1.5 g L^{-1} followed by Serni leaf extract 10 ml aqueous solution L^{-1})

Table A : Details of the modules tested for management of okra shoot and fruit borer

Modules	1st spray/application	2nd spray	3rd spray
M_1	Imidachloprid 70 WS 10 g kg^{-1} seed treatment	*Beauveria bassiana* 5g L^{-1}	NSKE 5%
M_2	Imidachloprid 70 WS 10 g kg^{-1} seed treatment	*Beauveria bassiana* 5g L^{-1}	Custard apple leaf extract @ 10 ml aqueous solution L^{-1}
M_3	Endosulfan 35 EC @ 0.06%	*B. thuringiensis* sub sp *kurstaki* @ 1.5g L^{-1}	Serni leaf extract @10 ml aqueous solution L^{-1}
M_4	Endosulfan 35 EC @ 0.06%	*B. thuringiensis* sub sp. *kurstaki* @1.5g L^{-1}	Maharukh leaf extract @ 10 ml aqueous solution L^{-1}
M_5	Deltamethrin 1.8 EC 0.09%	Neemazal 4 ml / L	Soapnut fruit extact10 ml aqueous solution L^{-1}
M_6	Lamda cyhalothrin 5 EC 0.005%	Kajara seed powder @ 0.5g L^{-1}	Karanj oil @10ml L^{-1}
M_7	Carbaryl 50 WDP 0.1%	Karanj oil @10ml L^{-1}	Madanphal fruit extract @ 10 ml aqueous solution L^{-1}
M_8	Profenofos 50 EC 0.05%	NSKE 5%	Garlic and chilli extract @ 10 ml aqueous solution L^{-1}
M_9	Cypermethrin10 EC 0.005%	NSKE 5%	Custard apple leaf extract @ 10 ml aqueous solution L^{-1}
M_{10}	Water spray	Water spray	Water spray

composed of alternate spray of chemical pesticides , biopesticides and botanicals have recorded low fruit infestation (17.07, 17.15, 17.20, 17.36 and 17.88 per cent fruit infestation, respectively) and were at par with each other.

Above results revealed that integrated approach consisting of alternate use of chemical pesticides, bio pesticides and botanical can be adopted for the management of okra shoot and fruit borer to reduce the chemical pesticide load on the crop and to decrease residue in okra fruits.

Effect of different modules on yield of okra crop :

The yield data on marketable fruits recorded in various treatments are presented in Table 3. Results revealed that highest yield of 36.56 q/ha was recorded in module M_9 (cypermethrin 10 EC 0.005 per cent, NSKE 5 per cent and custard apple leaf extract 10 ml aqueous solution L^{-1} as first, second and third spray, respectively) followed by module M_5 (deltamethrin 0.09 per cent, Neemazal 4ml L^{-1} and soapnut 10 ml aqueous solution L^{-1}) (36.29 q/ha), followed by module M_8 (Profenofos 50 EC 0.05 %, NSKE 5 % then garlic and chilli extract 10 ml aqueous solution L^{-1}) (36.11 q/ha), followed by M_4 composed of endosulfan 35 EC (0.06%) followed by *B thuringiensis* var. *kurstaki* @ 1.5 g L^{-1} , custard apple leaf extract 10 ml aqueous solution L^{-1} (35.72 q/ha) and M_3

Table 1 : Relative efficacy of different modules against okra shoot and fruit borer, *E.vittella* (on number basis)

Modules	Per cent fruit infestation			Pooled mean
	I spray	II spray	III spray	
M_1	34.46 (35.94)*	27.48 (31.51)	18.87 (25.69)	26.94 (31.05)
M_2	35.0 (36.27)	24.73 (29.73)	21.67 (27.70)	27.14 (31.24)
M_3	16.20 (23.57)	15.45 (22.99)	16.68 (24.04)	16.11 (23.53)
M_4	16.43 (23.79)	14.99 (22.59)	16.25 (23.70)	15.89 (23.36)
M_5	15.51 (23.05)	16.58 (23.85)	17.06 (24.31)	16.38 (23.74)
M_6	15.58 (23.12)	23.00 (28.61)	21.46 (27.56)	20.01 (26.43)
M_7	20.67 (26.99)	21.32 (27.43)	23.56 (29.01)	21.85 (27.81)
M_8	17.41 (24.57)	17.53 (24.66)	16.12 (23.63)	17.02 (24.29)
M_9	16.42 (23.77)	16.71 (24.08)	17.63 (24.78)	16.92 (24.21)
M_{10}	38.16 (37.94)	34.53 (35.98)	35.76 (36.71)	36.15 (36.88)
S.E.±	1.22	0.99	0.60	0.94
C.D. at 5 %	3.62	2.93	1.77	2.77

Figures in parentheses are arcsine transformed values

Table 2: Relative efficacy of different modules against okra shoot and fruit borer, *E.vittella* on weight basis

Modules	Per cent fruit infestation			Pooled mean
	I spray	II spray	III spray	
M_1	32.57 (34.56)*	24.18 (29.44)	18.49 (25.43)	25.08 (29.81)
M_2	33.50 (35.42)	23.54 (29.01)	21.49 (27.59)	26.18 (30.67)
M_3	19.27 (27.00)	16.36 (23.82)	18.01 (24.46)	17.88 (25.09)
M_4	19.99 (26.66)	15.52 (23.18)	16.58 (23.99)	17.36 (24.61)
M_5	19.27 (27.00)	15.89 (23.49)	16.44 (23.87)	17.20 (24.79)
M_6	18.69 (25.58)	25.68 (30.42)	21.65 (27.73)	22.01 (27.91)
M_7	23.06 (27.89)	25.46 (30.29)	23.78 (29.17)	24.20 (29.12)
M_8	19.64 (26.31)	16.76 (24.15)	15.06 (22.82)	17.15 (24.42)
M_9	19.54 (26.22)	16.35 (23.84)	15.32 (23.02)	17.07 (24.36)
M_{10}	39.86 (39.92)	35.85 (36.77)	36.96 (37.44)	37.56 (38.04)
S.E.±	0.52	0.56	0.59	0.57
C.D. at 5%	1.21	1.67	1.76	1.55

*Figures in parentheses are arcsine transformed values

(endosulfan 35 EC (0.06%) , *B. thuringiensis* var. *kurstaki* @ 1.5 g L^{-1} and Serni leaf extract 10 ml aqueous solution L^{-1}) (35.06 q/ha) and were at par with module M_9.

Table 3 : Effect of different modules on yield of okra

Modules	Marketable fruit yield q/ha
M_1	30.18
M_2	31.14
M_3	35.06
M_4	35.72
M_5	36.29
M_6	34.00
M_7	32.25
M_8	36.11
M_9	36.56
M_{10}	24.72
S.E.±	0.64
C.D. at 5%	1.91

The present findings confirm the results of Hegde (2004) who reported that use of garlic and chilli extracts and NSKE (5%) alternated with cow urine (10%) were superior in reducing damage caused by okra shoot and fruit borer and increasing the yield. The present findings also confimed with those of Kaur (2002) who reported that the marketable fruit yield was highest in the treatment cypermethrin 30 g a.i. /ha. Effectiveness of deltamethrin 2.8 EC was confimed with those of Chiranjeevi (1999). He reported that deltamethrin recorded significantly higher yield of marketable fruits and lowest per cent fruit damage. The present findings of *B. thuringiensis* var. *kurstaki* @ 1.5 g L^{-1} confirm the results of Desai and Kapadia (2009) and Patel and Vyas (2000). They reported effectiveness of *B. thuringiensis* var. *kurstaki* against shoot and fruit borer and increase in fruit yield. Similarly effectiveness of NSKE (5%) was reported by Alagar and Sivasubramanian (2006) in reducing the fruit damage by *E. vittella* and increase in yield of okra.

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RESEARCH ARTICLE

Epidemiology of post-harvest black mould fruit rot of pomegranate (*Punica granatum* L.) caused by *Aspergillus niger*

■ M. K. KHOKHAR[1]*, GOKUL MEENA[2] AND R.G. JAT[2]

[1]Department of Plant Pathology, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, UDAIPUR (RAJASTHAN) INDIA

[2]Department of Plant Pathology, S.K.N. College of Agriculture, Rajasthan Agricultural University, JOBNER (RAJASTHAN) INDIA

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*Corresponding author:
khokharmk@rediffmail.com

ABSTRACT

Lab experiment was conducted at Dept. of Plant Pathology, SKN College of Agriculture, Jobner, Jaipur, Rajasthan, during 2008-09 and is was found that all the fruits exhibited symptoms of the rot when fruits were inoculated by cork borer wounding method at unripe, semi-ripe and ripe stage. Severity of the rot was maximum in fruit inoculated at ripe stage. Temperature had a profound effect on development of rot, incidence and severity were lowest in fruits pre-disposed at 0^0C. The maximum severity was found on fruits pre-disposed to 30^oC. Lowest severity of the rot occurred when fruits were pre-disposed at 50 per cent relative humidity. The severity of the rot increased with increasing levels of relative humidity. Maximum severity of the rot was observed on fruits pre-disposed to 100 per cent relative humidity.

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INTRODUCTION

Pomegranate (*Punica granatum* L.) is an important favourite fruit of tropical, sub-tropical and arid regions. It belongs to the family Punicaceae and is believed to native of the middle East (Iran and adjoining countries) and spread to most tropical and subtropical countries of the world. It is extensively cultivated in Iran, Egypt, Pakistan, Spain, Morocco, Afghanistan and in some place of Myanmar, China, Japan, California, South Italy and Bulgaria (Mitra *et al.*, 1999). Pomegranate fruits are the good sources of carbohydrates and mineral such as Ca, Fe and S and a moderate source of pectin (Waskar, 2006). The pomegranate fruit suffered from several fruit rot diseases (Kanwar and Thakur, 1973). The incidence was found to be 10-20 per cent on pomegranate fruits.

MATERIALS AND METHODS

Mature pomegranate fruits were inoculated with the uniform amount of inoculum by cork-borer wounding method (A hole of 2 mm diameter and 2 mm depth was made with the help of a sterilized cork borer). The inoculum was placed in the hole and the host tissue was replaced on the hole and effect of fruits ripeness (unripe fruits, semi-ripe fruits and ripe fruits stage of maturity), temperature (0, 5, 10, 15, 20, 25, 30, 35 and 40^0C) and relative humidity (40, 50, 60, 70, 80, 90 and 100 per cent) were tested on disease development. Solution of sulphur acid (H_2SO_4) was used to produce different levels of relative humidity according to the procedure described by Buxton and Mellanby (1934). The inoculated fruits were placed in polythene bags (fruit ripeness) and desiccator (relative humidity) inoculated at 25 ± 1^0C in BOD incubators. The experiment was arranged in Completely Randomized Design. Data on incidence and severity of the rot were recorded after

3rd and 6th day inoculation.

RESULTS AND DISCUSSION

In all the stages of ripeness, cent per cent incidence of the rot was recorded on both 3rd and 6th days after inoculation (Table 1). Among the three stages the ripe stage, was found to be significantly (P=0.05) most susceptible to the fungus. The difference was highly significant (P=0.05) at unripe, semi-ripe and ripe stage at 3rd and 6th days after inoculation. Symptoms of various rots in different fruits did not appear when inoculated at the immature stage as have been reported by other workers (Hasija and Batra, 1979 and Blancard *et al.*, 1984). However, in the present study, *Aspergillus niger* was found to exhibit symptoms in all the stages and maximum severity was found at ripe stage of fruits. Temperature had a

Table 1 : Incidence and severity of black mould fruit rot in pomegranate fruits inoculated at different stages of ripeness and incubated after 3rd and 6th days at 25±1^{0}C

Stage of fruits at the time of inoculation	*Aspergillus niger*		
	Incidence*(%)	Severity* (%)	
	3rd days after inoculation	6th days after inoculation	6th days after inoculation
Unripe	100	4.00	5.00
Semi-ripe	100	6.00	7.50
Ripe	100	9.00	20.00
S.E.±	-	0.10	0.14
C.D. at 5%	-	0.31	0.45

*Average of four replications

Table 2 : Effect of temperature on incidence and severity of black mould fruit rot of pomegranate fruits incubated after 3rd and 6th days at 100 per cent relative humidity

Temperature (^{0}C)	*Aspergillus niger*		
	Incidence*(%)	Severity* (%)	
	3rd days after inoculation	3rd days after inoculation	6th days after inoculation
0-5^{0}C	0.00	0.00	0.00
10^{0}C	100	2.40	4.50
15^{0}C	100	3.50	6.00
20^{0}C	100	6.50	8.50
25^{0}C	100	7.50	13.50
30^{0}C	100	9.75	19.50
35^{0}C	100	8.50	13.75
40^{0}C	100	6.00	9.50
S.E.±	-	1.24	1.97
C.D. at 5%	-	3.61	5.74

*Average of four replications

Table 3 : Effect of different levels of relative humidity on incidence and severity of black mould fruit rot of pomegranate fruits incubated after 3rd and 6th days at 25±1^{0}C

Relative humidity (per cent)	*Aspergillus niger*		
	Incidence* (%)	Severity* (%)	
	3rd days after inoculation	3rd days after inoculation	6th days after inoculation
40	100	0.00	0.00
50	100	0.00	4.00
60	100	2.50	6.50
70	100	5.50	9.50
80	100	7.50	16.50
90	100	8.50	20.50
100	100	9.50	21.00
S.E.±	-	0.14	0.31
C.D. at 5%	-	0.41	0.92

*Average of four replications

profound effect on the symptoms of the rot appeared at a temperature range from 10°C to 40°C on both 3rd and 6th days of inoculation (Table 2). The severity was maximum at 30°C followed by 35°C, 25°C, 40°C, 20°C, 15°C and 10°C. At temperature 0-5°C, no disease was observed. Maximum decay of different fruits by various pathogens have been recorded at 15-30°C (Pathak, 1980; Bhargava, 1972; and Leong *et al*. (2006). In the present study, severity of black mould rot was also observed to be maximum at 30°C. Symptoms of the rot did not appear upto 6th day of inoculation in fruits kept at 0°C. Probably the temperature suppressed the activity of the pathogen and favoured host tissue resistance.

Relative humidity plays an important role in disease development. All the fruits inoculated with the pathogen showed symptoms of the rot at all the levels of relative humidity tried (Table 3). At 40 and 50 per cent relative humidity, the rot did not appear even after three days of inoculation. The severity of the rot increased with the increasing level of relative humidity and maximum severity of the rot was observed at 100 per cent relative humidity on both 3rd and 6th days after inoculation. Although, severity of rot did not differ significantly (P=0.05) at 90 and 100 per cent R.H. on both 3rd and 6th days after inoculation. High relative humidity is known to enhance fruit rot of different kinds (Pathak, 1980 and Moreau, 1960). In the present study, the rot increased in severity with the increase in levels of relative humidity.

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IJPP

RESEARCH ARTICLE

Effect of date on sowing and correlation of weather parameters on the incidence of anthracnose of greengram

■ SUNIL KULKARNI[1*] AND V. I. BENAGI[2]

[1*]Department of Plant Pathology, Krishi Vigyan Kendra, [U.A.S.(R.)], BIDAR (KARNATAKA) INDIA
[2]Department of Plant Pathology, University of Agricultural Sciences, DHARWAD (KARNATAKA) INDIA

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*Corresponding author:
kvksunil@gmail.com

ABSTRACT

Greengram one of the important pulse crops of India, is being affected by several foliar diseases among which anthracnose is the most important. The crop sown on 4th June recorded significantly less disease severity, which was enhanced in subsequent sowing dates because the weather conditions were very much congenial that is moderate temperature coupled with higher humidity. Correlation of weather parameters indicated that maximum and minimum temperatures had significantly negative correlation with disease. However, correlation coefficient with relative humidity and rainfall were positive but non-significant.

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INTRODUCTION

Greengram [*Vigna radiata* (L.) Wilczek] is an ancient and well known leguminous crop of Asia. It is quite versatile crop grown for seeds, green manure and forage and it is also considered as "Golden bean". Greengram is one of the important pulse crops, of India. Among the major diseases of greengram, anthracnose caused by *Colletotrichum truncatum* (Schw.) Andrus and Moore is a major disease. The disease severity varying from 18.2 to 86.57 per cent have been reported in northern Karnataka (Laxman,2006). The yield losses caused by anthracnose is proportional to the disease severity and varies remarkably depending on the stage of infection, genotypes and environmental conditions. To over come some of these problems, the present investigations were undertaken to study the effect of sowing dates and weather factors on severity of the disease to understand their practical utility in integrated disease management strategy of anthracnose.

MATERIALS AND METHODS

A field experiment was conducted during *Kharif* 2007 and 2008 at ARS, Bidar to assess the progress of anthracnose at different time interval in different dates of sowing. A replicated field trial was carried out to explore the possibility of disease escape.

The experiment was conducted in Randomized Block Design with four replications. The first date of sowing was done with highly susceptible variety Chinamung on 4th June and subsequent sowings were done at weekly interval. Totally six different dates of sowings were undertaken. The severity of anthracnose was recorded at 40 DAS on five randomly selected plants using a disease rating scale 0 to 9 (Mayee and Datar,1986) Further, these ratings were converted to per cent disease index (PDI). The meteorological data for the experimental period *viz.,* maximum and minimum temperatures, rainfall and relative humidity (morning and evening) were recorded during the crop growth period for each sowing.The correlation between anthracnose severity and weather parameters was made. Further grain yield was recorded.

RESULTS AND DISCUSSION

A field experiment was conducted during *Kharif* season of 2007 and 2008 with six different sowing dates starting from

4th June to 9th July at weekly intervals at Agricultural Research Station, Bidar to know the effect of different dates of sowing and the meteorological conditions associated with the disease development. The information on the incidence of disease as affected by different dates of sowing and also to know the influence of meteorological conditions in disease development will be very much useful to adjust the sowing times for growing good crop under very low disease pressure.

Effect of sowing dates :

Effect of different sowing dates on disease severity is depicted in Table 1. During 2007, there was a significant difference in the severity of anthracnose at different sowing dates. The per cent disease index varied from 24.29 to 59.87 per cent. The least PDI was recorded on crop sown on 4th June (24.29%) and was found on par with PDI of the crop sown on 11th June (26.10%), while the highest PDI was recorded on crop sown on 9th July (59.87%).

Similar results were obtained during 2008 also. The least severity of 25.77 per cent was recorded on crop sown on 4th June, while maximum PDI on crop sown on 9th July (61.24%). The mean PDI ranged from 25.03 to 60.56 per cent. The mean data of two years indicated the same trend as observed in individual years with respect to per cent disease index of anthracnose.

The grain yield in both the years indicated that higher yields (9.61 q/ha and 9.18 q/ha) were obtained in 4th June sowing of 2007 and 2008, respectively. The mean yield data revealed that highest mean yield of 9.40 q per ha was obtained in crop sown on 4th June followed by 11th June (8.83 q/ha). The results are similar to Mittal (1998) who reported that early sown blackgram crop suffered least due to low inoculum potential and unfavourable weather conditions for pathogen, whereas late sown crop suffered more because of ready availability of inoculum build up in early sown crop. Similar observations were made by Naidu and Chandrika (1997) in case of leaf spot of groundnut and Das (2005) in foliar diseases of greengram.

Effect of weather factors :

In the present study, severity of anthracnose of greengram was found to be influenced by environmental factors, which prevailed during crop growth period. Table 2 indicates that in both the years, the crop sown during 4th and 11th June recorded a lower per cent disease index coupled with higher yield. This could be due to higher temperature of 31^{0}C during the crop growth period coupled with lower humidity (88–89%) which were less congenial to the disease development. Whereas, the disease severity was maximum at the end of June month onwards. During that period, the weather conditions were very much congenial *i e.*, moderate temperature of 29^{0}C coupled with higher humidity of 90 to 92 per cent, with respect to rainfall received with range of 173.60 to 332.08 mm, though the amount received was less compared to early sowings but there was frequent rains received during crop growth period. The disease coincidence of the favourable period with stage of the crop led to considerable increase in disease severity. Chambers (1969) reported that amount of rain was found to be of less importance than prolonged wetness with high humidity which are necessary for infection by *C. truncatum* in bean.

Correlation coefficients between disease severity and weather parameters during both the years (pooled) revealed that there was significantly negative correlation between maximum and minimum temperatures with correlation coefficient of -0.782 and -0.600, respectively while, relative humidity morning (0.517), relative humidity evening (0.389) and rainfall (0.329) were positively correlated with PDI but non-significant (Table 3). Similar results were also reported by Kumar *et al.* (1999).

In the present study, the crop sown on first fortnight of June recorded minimum disease severity compared to rest of the dates of sowings. This clearly indicated that crop sown during this period suffers less, which may be due to low inoculum potential, whereas the late sown crop suffers more because of the readily available inoculum in the early sown crops. Low disease severity in first fortnight sowing may be

Table 1: Effect of date of sowing on percent disease index of anthracnose and yield of greengram during *Kharif* 2007 and 2008

Sr. No.	Sowing date	Per cent disease index at 40 DAS			Grain yield (q/ha)		
		Kharif -07	*Kharif* -08	Mean	*Kharif* -07	*Kharif*-08	Mean
1.	4th June	24.29 (29.52)*	25.77 (30.50)	25.03	9.61	9.18	9.40
2.	11th June	26.10 (30.72)	27.67 (31.73)	26.89	9.06	8.60	8.83
3.	18th June	28.78 (32.44)	29.65 (32.99)	29.22	7.87	7.34	7.61
4.	25th June	32.91 (35.00)	35.07 (36.31)	33.99	6.91	6.59	6.75
5.	2nd July	52.17 (46.24)	55.45 (48.13)	53.81	5.97	5.43	5.70
6.	9th July	59.87 (50.69)	61.24 (51.50)	60.56	5.34	5.02	5.18
	S.E.±	0.68 2.07	0.70		0.19	0.20	
	C.D. at 5%		2.10		0.56	0.60	

*values in parenthesis are arcsine transformed values

Table 2: Effect of dates of sowing and environmental factors in relation to anthracnose of greengram caused by *Colletotrichum truncatum* during *Kharif* 2007 and 2008

Sr. No.	Date of sowing	PDI at 40 DAS	Temperature (^{0} c)		Relative humidity (%)		Total rainfall (mm)
			Maximum	Minimum	Morning	Evening	
***Kharif* 2007**							
1.	4th June	24.29	31.80	22.10	88.16	53.23	155.12
2.	11th June	26.10	30.95	21.88	89.55	58.04	318.64
3.	18th June	28.78	30.26	21.52	91.86	61.36	332.08
4.	25th June	32.91	29.93	21.35	92.47	62.39	330.96
5.	2nd July	52.17	29.87	21.27	92.25	61.95	313.04
6.	9th July	59.87	29.96	21.16	92.05	60.73	309.12
***Kharif* 2008**							
1.	4th June	25.77	31.73	21.47	89.02	57.39	356.16
2.	11th June	27.67	30.95	21.33	90.00	59.79	355.60
3.	18th June	29.65	30.24	21.05	90.70	62.61	325.92
4.	25th June	35.07	29.91	21.03	90.57	61.46	202.72
5.	2nd July	55.45	29.25	21.09	90.29	60.05	173.60
6.	9th July	61.24	29.22	21.07	91.11	60.86	202.72

Table 3: Correlation studies of weather parameters with anthracnose severity on greengram

Sr. No.	Weather parameters	Correlation coefficient (r)		
		2007	2008	Pooled
1.	Maximum temperature (^{0}C)	- 0.680*	- 0.869**	- 0.782**
2.	Minimum temperature (^{0}C)	- 0.823**	- 0.551*	- 0.600*
3.	Relative humidity (%) morning	0.619*	0.605*	0.517
4.	Relative humidity (%) evening	0.516	0.196	0.389
5.	Rainfall (mm)	0.331	- 0.838**	0.329

* and ** Indicated significance of value at P=0.05 and 0.01, respectively

attributed to the non-congenial weather factors (higher temperature coupled with lower humidity) for the development of the disease. Hence, alternation of the date of sowing of crop always plays an important role in disease escape due to unfavourable weather conditions for infection.

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IJPP

RESEARCH ARTICLE

Adoption gap in integrated pest management technology of cotton

■ B. D. SABLE* AND R. P. KADAM

Department of Extension Education, College of Agriculture, Marathwada Krishi Vidyapeeth, PARBHANI (M.S.) INDIA

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* Corresponding author:
kadam75@rediffmail.com

ABSTRACT

The study was undertaken in Parbhani district of Marathwada region in Maharashtra state, as in this district, MKV has implemented ICAR sponsored project on integrated pest management during the year 2010- 11 in ten villages of three talukas. The study of adoption gap was made in terms of personal characteristics of cotton growers. involvement of cotton growers in performing social participation. In the present study, majority of respondents were observed in farm experience of 9-31 years, having education upto secondary school level. Majority of them were having medium family size. Most of the them were having small landholding and their family income was from Rs. 57,326/- to Rs. 2,82, 190/-. In this present study, it was observed that majority of the respondents had medium level of adoption gap.

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INTRODUCTION

Cotton, being a cash crop, is of great economic importance for the Indian farming community. Nevertheless, it is highly prone to a number of insect pests and diseases. A good crop with minimum pest attack brings prosperity, while a severe pest attack brings misery. Pests also became resistant to chemical pesticides and cause significant increase crop losses. Pesticides do not provide lasting control and so needed repeated applications. Continued use of pesticides builds up high level of toxic residues in food, ground water and air. Several important cash crops are now tested for pesticide residues before being accepted as import items by various countries. This is more so in the rainfed areas where opportunities for growing alternative crops are limited due to marginality of the production environment. Thus, pest is an important determinant of the prosperity of the rainfed farmers. Excess use of insecticides also increases cost of cultivation. This knowledge has led to a shift towards eco-friendly technologies in pest management. Integrated pest management therefore, has emerged as a solution to avoid excessive use of insecticides. Integrated pest management is the integrated use of pest control strategies in a way that not only reduces pest population to satisfactory level but is sustainable and non-polluting. It is therefore necessary to see the contents of use of integrated pest management by cotton growers. The pest problem though cannot be eliminated altogether, it can be minimized through application of appropriate pest management strategy, be it chemical pest control, biological control or integrated pest management (IPM). The chemical-based pest management, however, has been losing its efficiency mainly due to rising problem of insecticide resistance. An IPM package comprised of cultural practices, resistant varieties, insect scouting, beneficial insects and the selective use of insecticides was developed and tested under field conditions. The effectiveness of IPM gets maximized when all growers use them on a community basis over area-wide. The goal of IPM does not aim for reduction of the insect population to zero but merely to a level below the economic damage. IPM strategies focus on an appropriate mixture of eco-friendly practices. It includes eco-friendly practices which are grouped as cultural, mechanical, biological and chemical. Adoption gap means operationalized as the gap between recommended IPM practices and actual adoption of

IPM practices by the cotton growers. Low adoption gap means maximum adoption, and similarly high adoption gap means minimum adoption of IPM practices.

MATERIALS AND METHODS

For the study, Parbhnai district was selected purposively because it has implemented IPM Project of ICAR through Marathwada Krishi Vidyapeeth. Eight villages were selected purposively as it has IPM followers in cotton crop of Parbhani district. From the each selected taluka, four villages were selected purposively *viz.,* in Manwat taluka Kolhawadi, Irlad, Ambegaon and Rudhi and in Selu taluka Nipani Takli, Digras, Rajewadi and Kawaddhan. From each of the villages fifteen numbers of the respondents were selected. Thus, 120 respondents were selected for study. Ex. post facto study method was used for research study. The data were collected with the help of structured schedule. The respondents were contacted personally at their home or at their farms as per their convenience. Keeping in view the objectives of the study an interview schedule was prepared.

RESULTS AND DISCUSSION

The experimental findings of the present study have been presented in the following sub heads:

Personal, socio-economic and psychological characteristics of cotton growers :

It was worthy to note from Table 1 that about 67.51 per cent of respondents were having medium farming experience (9 to 31 years of farm experience). There were 14.16 per cent of the respondents who were having low farming experience (up to 8 years of farm experience). As much as 18.33 per cent of the respondents were having high farming experience (32 years and above farm experience). Majority of respondents 55.01 per cent of the respondents were educated up to secondary school level (5th to 10th std.), while 18.33 per cent respondents were illiterate and 14.16 per cent of the respondents were educated up to primary level (1st to 4th std.), 7.50 per cent of respondents were educated up to college level (above 12th), 5.00 per cent of the respondents were educated up to higher secondary school level (11th and 12th std.). As regards land holding of the respondents, it was observed from Table 1 that 35.01 per cent of respondents were small farmers (1.1 to 2 ha) followed by 34.16 per cent of respondents were semi-medium farmers (2.1 to 4 ha), 17.51 per cent of the respondents were medium farmers (4.1 to 10 ha), 9.16 per cent and 4.16 per cent of them were marginal farmers (up to 1 ha) and big farmers were having 10.1 ha and above ha. land, respectively. It is revealed from Table 1 that about 79.16 per cent of respondents were having medium size of family (3 to 8 members). There were 10.83 per cent of the respondents having small size of

Table 1 : Distribution of respondents according to their personal, socio-economic and psychological characteristics (n=120)

Sr. No.	Category	No.	Per cent
A	**Farm experience**		
	Low (up to 8 years)	17	14.16
	Medium (9 to 31 years)	81	67.51
	High (32 years and above)	22	18.33
B	**Education**		
	Illiterate	22	18.33
	Primary (1st Std. to 4th Std.)	17	14.16
	Secondary (5th Std. to 10th Std.)	66	55.01
	Higher Secondary (11th and 12th Std.)	06	05.00
	College education (above 12th)	09	07.50
C	**Size of land holding**		
	Marginal farmers (up to 1 ha)	11	09.16
	Small farmers (1.01 to 2ha)	42	35.01
	Semi-medium farmers (2.01 to 4 ha)	41	34.16
	Medium farmers (4.01 to 10 ha)	21	17.51
	Big farmers(10.01ha and above)	05	04.16
D	**Size of family**		
	Low (up to 2)	13	10.83
	Medium (3 to 8)	95	79.16
	High (9 and above)	12	10.01
E	**Annual income**		
	Low (below ` 57325)	10	08.33
	Medium (` 57326 to ` 282190)	92	76.66
	High (` 282191 and above)	18	15.01
F	**Social participation**		
	Low (up to 0.16)	75	62.51
	Medium (0.17 to 1.03)	38	31.66
	High (1.04 and above)	07	05.83
G	**Economic motivation**		
	Low (Up to 20)	12	10.00
	Medium (21 to 23)	87	72.50
	High (24 and above)	21	17.50
H	**Cosmopoliteness**		
	Low (up to 4)	13	10.83
	Medium (5 to 11)	96	80.01
	High (12 and above)	11	9.16
I	**Knowledge level**		
	Low (up to 14)	27	22.50
	Medium (15 to 24)	75	62.50
	High (25 and above)	18	15.00

family (up to 2 members). As much as 10.01 per cent of the respondents were having large of family (9 members and above).

The data presented in Table indicate that 76.66 per cent of the respondents were having annual income between Rs. 57,326/- to Rs. 2,82,190/-. However, 15.01 per cent of respondents were having high annual income *i.e.* Rs. 2,82,191/ - and above. While 8.33 per cent respondents were in low annual income category *i.e.* income Rs. 57,325 /- and below. It was noticed that majority (62.51%) of respondents were having low level of social participation followed by medium level of social participation (31.66%). While, 05.83 per cent of the respondents were having high level of social participation. It is observed that majority (72.50%) of respondents had medium level of economic motivation; followed by 17.50 per cent of the respondents were having high level of economic motivation. Whereas, 10.00 per cent of them had low level of economic motivation. The data of Table 1 also revealed that majority 80.01 per cent of the respondents were found to have medium cosmopoliteness. A very less percentage 10.83 and 9.16 per cent, respectively, had low and high cosmopoliteness. It was also observed that majority (62.50 per cent) of respondents had possessed medium level of knowledge followed by 22.50 per cent had low and 15.00 per cent had high level of knowledge about IPM technology of cotton growing.

A critical look at the Table 2 revealed that respondents were very high adoption gap *i.e.* 91.66 per cent as observed about keeping proper spacing for rainfed cotton cultivation. Whereas observed (81.25 %) adoption gap about recommended dose of NPK. In case of chemical control of sucking pest by dimethoate and fipronil it was observed 80.00 per cent of adoption gap. 77.9 per cent of adoption gap was observed about adoption of recommended seed treatments at the time of sowing of cotton. Whereas, 71.25 per cent adoption gap was observed about grazing of sheep and goats after last picking. More adoption gap (70.83 %) was observed about installing perchers for birds.

Adoption gap about recommended height for sex pheromone trap was observed 70.83 per cent. Whereas 65.00 per cent of adoption gap was observed about control of ballworms by cloropyriphos. Further, result showed that, 60.83

Table 2 : Distribution of respondents according to their adoption gap of recommended practices of IPM technology in cotton

Sr. No.	Recommended practices	Adoption gap (%)
1.	Selection of medium to heavy well drained soil	35.00
2.	Use of 15-25 cl of FYM per ha.	57.50
3.	Grazing of sheep and goats after last picking	71.25
4.	Deep ploughing	6.66
5.	Use of 2.5-3.0 kg seed per ha. For Bt. cotton	3.33
6.	Sowing period for rainfed cultivation (15 June to 15 July)	2.08
7.	Seed treatment	77.91
8.	Proper spacing for rainfed cultivation (120 X 45 cm)	91.66
9.	Recommended first dose of half N and full P_2O_5 and K_2 at the time of sowing	5.41
10.	Recommended dose of NPK per ha. (125:62.5:62.5)	81.25
11.	Depth of fertilizer application (5-10 cm)	37.91
12.	Sex pheromone trap (5-7/ha)	27.91
13.	Installing perchers for birds	70.83
14.	Spraying of 5% neem seed kernel extract	16.66
15.	2-3 sprayings of neem kernel after 15 days interval for biological pest control	47.50
16.	Use of Tricogramma cards	14.16
17.	Crysoparla conservation	60.83
18.	Control of sucking pest by Dimethoate, Fipronil	80.00
19.	Control of bollworms by Cloropyriphos	65.00
20.	Control of mealy bug by *Verticilium licani*	54.58
21.	Recommended height for sex pheromone traps (45 cm)	70.83
22.	Intercropping	10.41
23.	Intercultural operation and weed control (3 hoeings)	40.41
	Composite adoption gap	44.47

per cent of adoption gap was observed about crysoparla conservation. Whereas 57.50 per cent and use of recommended FYM per ha. in soil for better crop production. Further it was revealed that 54.58 per cent adoption gap was observed about control of mealy bug by *Verticilium licani.*

In mechanical practices, 47.50 per cent adoption gap was observed about number of sprayings of neem kernel after 15 days of interval for pest control. Further, the adoption gap about intercultural operation was observed 40.41 per cent. Adoption gap of 37.91 per cent gap was observed about proper depth of fertilizer application.

Further, from Table 2 it was concluded that adoption gap of 35.00 per cent was observed for type of soil recommended for cultivation of cotton. It was observed that there was 27.91 per cent gap in adoption of sex pheromone trap per ha. Further study revealed that only 16.66 per cent gap of adoption was observed about spraying of 5 per cent neem seed kernel extract. While studying the adoption gap about biological practices, respondents were having 14.16 per cent adoption gap for use of Tricogramma cards. Further, 2 revealed that adoption gap about intercropping was 10.41 per cent.

In case of deep ploughing before sowing of cotton, it was observed very low adoption gap (6.66 %). Majority of respondents comes under 5.41per cent adoption gap about recommended first dose of half N and full P_2O_5 and K_2 at the time of sowing. It was also observed that respondents were having low adoption gap (3.33 %) about use of recommended seed rate (2.5-3.0 kg/ha) for Bt. cotton. Only 2.08 per cent adoption gap was observed about sowing period for rainfed cultivation.

Composite gap was determined by summation of adoption gap of all practices divided by number of recommended practices. From Table 2 it was observed that over all composite adoption gap about recommended practices of IPM technology by cotton growers were having 44.47 per cent, hence from obtained result it was concluded that 55.53 per cent of adoption was observed about recommended IPM technology.

Relationship between characteristics of cotton growers with adoption gap :

It was observed from Table 3 that out of ten independent variables, farm experience had positive and significant relationship with adoption gap of cotton growers regarding IPM technology in cotton at 0.05 per cent level of probability. Whereas education, annual income, social participation, cosmopoliteness and knowledge level had negatively significant relationship with adoption gap at 0.01 per cent level of probability. Remaining variables such as land holding, size of family and economic motivation had non-significant relationship with adoption gap of cotton growers regarding IPM technology in cotton.

Table 3 : Relationship between the profiles of respondents with adoption gap of IPM technology in cotton

Sr. No.	Category	Correlation coefficient 'r'
1.	Farm experience	0.204^{*}
2.	Education	-0.671^{**}
3.	Land holding	-0.182^{NS}
4.	Size of family	-0.026^{NS}
5.	Annual income	-0.250^{*}
6.	Social participation	-0.425^{**}
7.	Economic motivation	0.086^{NS}
8.	Cosmopoliteness	-0.341^{**}
9.	Knowledge level	-0.782^{**}

Conclusion :

It could be concluded that most of the respondents had medium level of farm experience. Farmers were educated up to secondary school level. One third of respondents (35.01%) were small farmers. The educated farmers know the importance of small family so the majority of farmers had medium family size and majority of farmers were grouped into medium annual income. Due to low knowledge, low encouragements and limited scope in social activity, the farmers possessed low level of social participation. Most of the respondents (72.50%) had medium level of economic motivation. Majority of the respondents (80.01%) had medium level of cosmopoliteness. Most of the respondents (62.50%) had medium level of knowledge level. As regards adoption gap, most of the respondents (61.66 %) had medium level of adoption gap. These findings are in line in the with observation made by Sorate (2011), Kumar (2011), Kadam (2003), Dhakne (2008) and Deshmukh *et al.* (2011).

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RESEARCH ARTICLE

Evaluation of combination of potassium phosphonate and *Trichoderma harzianum* on management of *Phytophthora* foot rot of black pepper (*Piper nigrum* L.) under arecanut cropping system

■ M.S. LOKESH[1]*, S.V. PATIL[2], S.B.GURUMURTHY[3], M.G. PALAKSHAPPA[4] AND M. ANANDARAJ[5]

[1]Department of Plant Pathology, AICRP on Spices, Horticulture Research Station (U.H.S.) Sirsi, UTTARA KANNADA (KARNATAKA) INDIA

[2]Department of Agronomy, College of Horticulture, (U.H.S.), Sirsi, UTTARA KANNADA (KARNATAKA) INDIA
Email: sangappavpatil@gmail.com

[3]Department of Agricultural Microbiology, College of Horticulture, (U.H.S.), Sirsi UTTARA KANNADA (KARNATAKA) INDIA
Email: sbgurmurthy@yahoo.com

[4]Department of Plant Pathology, AICRP on Sesame and Niger, University of Agricultural Sciences, DHARWAD (KARNATAKA) INDIA
Email: pal_uasd@gmail.com

[5]Indian Institute of Spices Research, CALICUT (KERALA) INDIA
Email: anandaraj@spices.res.in

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*Corresponding author:
lokeshsirsi@rediffmail.com

ABSTRACT

Phytophthora foot rot (*Phytophthora capsici* Leonian) was significantly least on black pepper (*Piper nigrum* L.) vines wherein disease incidence was minimum leaf yellowing, least defoliation, minimum death of vines and highest yield (green berry yield and projected yield) due to protection of vines to foliage and root zone with application of potassium phosphonate (@ 0.3 %) as spraying (@ 2 l^{-vine}) and drenching (@ 3 l^{-vine}) and soil application of *Trichoderma harzianum* Rifai. (MTCC-5179) @ 50 g per vine with one kg of neem cake to the root zone during pre-monsoon (June) and peak monsoon (August). In case of farmers practice wherein only affected vines were applied with 1 per cent Bordeaux mixture to the foliage after appearance the disease. Those vines registered maximum leaf yellowing and maximum defoliation, maximum death of vines and lowest yield (green berry yield and projected yield).

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INTRODUCTION

Black pepper (*Piper nigrum* L.), the king of spices, and traditional historic spice is being cultivated as mixed crop in arecanut and coffee cropping system and also as pure crop since ancient times in India. Black pepper perennial woody climber is native of the Western Ghats of South India. The cultivation of crop in the world is mainly confined to India, Brazil, Indonesia, Malaysia, Thailand, Sri Lanka and Vietnam. In India, Black pepper is being cultivated in Kerala (96%), Karnataka (3%) and to a lesser extent in Maharashtra, Andhra Pradesh, Tamil Nadu and North Eastern regions in an area of

2.2 lakh ha with a production of 70,000 tonnes. During the year 2008-2009, India exported more than half of the pepper produced here, that is 25,250 tonnes valued at Rs. 414.00 crores. Indian pepper fetches a premium price in major international markets because of its preference and intrinsic quality (Thomas, 2010).

In Karnataka, black pepper is cultivated in Coorg, Uttara Kannada, Dakshina Kannada, Shimoga, Chikmagalore and Hassan districts. Among the diseases of this crop, Phytophthora foot rot caused by *P. capsici* Leonian is a major and serious malady, causing huge economic loss and is the major constraint in its cultivation in Uttara Kannada district. of Karnataka under arecanut cropping system.

However, there is lot of literature available on the disease control with use of contact and systemic fungicides and bioagents. But there is lack of information on use of potassium phosphonate and bioagents in combination for management of the disease in arecanut cropping system. Hence, an attempt was made to investigate the efficacy of potassium phosphonate and *Trichoderma harzianum* (MTCC-5179) and compared with the farmers practice for control of the disease.

MATERIALS AND METHODS

A field experiment on management of foot rot of black pepper was carried out by applying fungicides, bioagents and plant product like neem cake in a farmer's garden at Hosabale village, Sirsi taluka of Uttara Kannada district of Karnataka in central Western Ghats of India during 2006-07 to 2007-08 for two years. The object of the experiment was to know the efficacy of potassium phosphonate and *Trichoderma harzianum* combination on the disease management.

The vines were cultivated in arecanut as mixed crop, wherein the vines were trained to arecanut standards. The treatment details included fungicides, bioagents and their combinations. In each treatment, seven pepper vines were selected with seven replications. The treatments were taken as pre-monsoon and peak monsoon application, in June and August, respectively.

T. harzianum was obtained from Indian Institute of Spices Research, Calicut, Kerala and it was mass multiplied on moist wheat bran preparations (1:1 v/v) (Jahagirdar *et al.*, 2000). *T. harzianum* (50 g/ vine) was mixed with finely powder neem cake of 1 kg and was incorporated into top 10 cm layer of soil around the root zone during the month of June and August.

The fungicides *viz.,* Potassium phosphonate (0.3%), Bordeaux mixture (1%), copper oxychloride (0.2%) were applied as spraying (@ 2 l^{-vine}) and drenching (@ 3 l^{-vine}) along with biocontrol agent, T. *harzianum*. The treatments were compared with the farmers' practice wherein Bordeaux mixture (1%) was taken up as spraying once after the disease appearance and only tzo the affected vines.

Treatment details	
Treatment No.	Details
T_1	Potassium phosphonate (0.3 %) + *Trichoderma harzianum* (MTCC-5179)
T_2	Bordeaux mixture (1 %) spraying + Copper oxychloride (0.1 % a.i.) drenching
T_3	Farmers practice : 1 % Bordeaux mixture as spraying once after the disease appearance and only to affected vines

Number of vines showing leaf infection were recorded and presented as per cent leaf infection. For intensity of leaf infection, three areas (0.5 sq. m.) were randomly selected in the canopy of black pepper vines, preferably each at lower level, middle level and upper level of the canopy and number of leaves present and number of leaves infected by the disease were recorded and presented as per cent leaves infested by the disease.

Number of vines died due to the disease as death of vines were recorded and presented as per cent dead vines. Number of vines showing foliar yellowing and defoliation were recorded individually and presented as per cent disease index (PDI). For the intensity either foliar yellowing or defoliation grades were given based on the visual observations using the following scale, preferably in lower, middle and upper level and presented as foliar yellowing index/defoliation index.

Index	**Foliar yellowing /Defoliation**
0	Nil
1	Up to 25 %
2	25 to 50 %
3	More than 50 %

The treatments were applied twice in a year *i.e.*, June and August during 2006-2007 to 2007-2008. The observations on leaf infection, foliar yellowing, defoliation death of vines and yield (both green berry kg^{-vine} and projected yield kg^{-ha}) were recorded. The observations made for the disease incidence recorded from the experimental vines in the garden at different stages of disease development were subjected to statistical analysis as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Disease incidence of black pepper with respect to leaf infection (%), foliar yellowing (PDI) defoliation (PDI), death of vines (%) and yield (both green berry kg^{-vine} and projected yield kg^{-ha}) were presented for each year *i.e*, 2006-2007and 2007-2008 and also presented and pooled from 2006-2007 to 2007-2008 data separately.

The data revealed during the year 2006-07 that disease incidence of Phytophthora foot rot of black pepper was with respect to less leaf infection (5.60 per cent), less foliar yellowing (10.00 PDI), less defoliation (13.33 PDI), no death of vine and highest green berry yield of 1.80 kg per vine when vines were treated during onset of monsoon (June) and again during third week of August with Potassium phosphonate (@ 0.3 per cent) as spraying (@ 2 l^{-vine}) and drenching (@ 3 l^{-vine}) and soil application of *Trichoderma harzianum* (MTCC-5179) @ 50 g^{-vine} with one kg of neem cake to the root zone. This was closely followed by chemical check with application of (1 %) Bordeaux mixture as spraying (@ 2 l^{-vine}) and copper oxychloride (@ 0.1 % *a.i.*) as drenching (@ 3 l^{-vine}) where in less leaf infection (6.80 per cent), less foliar yellowing (16.66 PDI), low defoliation (19.98 PDI), less death of vine (4.0 per cent) and more green berry yield of 1.74 kg per vine were recorded. Black pepper vines were severely affected by the disease *viz.*, more leaf infection (20.00 per cent), more foliar yellowing (60.00 PDI) and high defoliation (56.66 PDI), more death of vines (12.00 per cent) with green berry yield of 1.45 kg per vine wherein the farmers practice of application of fungicide *i.e.,* one per cent Bordeaux mixture as spray after appearance of the disease (Table 1).

The results during the year 2007-2008 indicated that black pepper vines were least infected with Phytophthora foot rot of black pepper where the vines were protected with potassium phosphonate (@ 0.3 per cent) as spraying (@ 2 l^{-vine}) and drenching (@ 3 l^{-vine}) and soil application of *Trichoderma harzianum* (MTCC-5179) @ 50 g per vine with one kg of neem cake to the root zone during pre monsoon (June 2007) and

Table 1: Management of Phytophthora disease of black pepper in farmers' field as adoptive trial (2006-2007)

Treatments	Leaf infection (per cent)	Foliar yellowing (PDI)	Defoliation (PDI)	Death of vine (Per cent)	Green berry yield (kg/vine)	Projected yield (kg/ha)**
T_1. Potassium phosphonate (0.3 %) + *Trichoderma harzianum* +1 kg neem cake	5.60 (9.40)	10.00 (18.36)	13.33 (21.33)	0.0 (0.00)	1.80 (7.70)	742.50
T_2. Bordeaux mixture (1 %) spraying + Copper oxychloride (0.1 % a.i.) drenching	6.80 (12.06)	16.66 (23.62)	19.98 (26.30)	4.0 (6.14)	1.74 (7.57)	717.75
T_3 Farmers, practice, Bordeaux mixture (1%) as spraying once after the disease appearance and only to affected vines	20.00 (24.60)	60.00 (50.76)	56.66 (48.87)	12.0 (17.16)	1.45 (6.91)	598.45
S.E. ±	3.77 (5.00)	2.23 (1.68)	1.96 (1.34)	2.30 (3.16)	0.06 (0.13)	
C.D. @ 5 %	11.63(15.41)	7.14(5.16)	6.05 (4.13)	7.07 (9.75)	0.18 (0.39)	

*arc sin transformed values ** 32 per cent dry age

Table 2 : Management of Phytophthora foot rot disease in black pepper (adaptive trial) (2007-2008)

Treatments	Leaf infection (per cent)	Foliar yellowing (PDI)	Defoliation (PDI)	Death of vines (%)	Green berry yield (kg/vine)	Projected yield (kg/ha)**
T_1.Potassium phosphonate (0.3 %) + *Trichoderma harzianum* + 1 kg neem cake	4.57 (10.67)*	14.28 (21.88)	12.92(20.91)	10.20(14.13)	0.77 (5.04)	319.39
T_2. Bordeaux mixture (1 %) spraying + Copper oxychloride (0.1 % a.i.) drenching	7.23 (13.71)	16.32 (23.76)	17.00 (24.04)	12.24(19.03)	0.72 (4.85)	291.54
T_3 Farmers practice, Bordeaux mixture (1%) as spraying once after disease appearance and only to affected vines	23.29 (28.59)	31.97 (34.32)	36.73 (37.23)	38.76 (38.38)	0.60 (4.44)	248.09
S.E. ±	2.35 (2.80)	1.86 (1.34)	2.07 (1.50)	3..33 (3.77)	0.03 (0.12)	14.61
C.D. @ 5 %	7.26 (8.78)	5.74 (4.14)	6.38 (4.63)	10.26 (11.60)	0.10 (0.35)	45.03

*arc sin transformed values , ** 33 per cent dry age

peak monsoon (Aug. 2007). The vines were depicting least leaf infection (4.57 %), least yellowing (14.28 PDI), defoliation (12.92 PDI) and death of vines (10.20 per cent) and highest green berry yield (0.77 kg per vine and 319.39kg /ha projected yield). In case of chemical check wherein the vines were applied with (1 per cent) Bordeaux mixture as spraying (@ 2 l^{-vine}) and drenching (@ 3 l^{-vine}) with copper oxychloride (@ 0.1 per cent a.i.) during June and August 2007, exhibited low incidence of leaf infection (7.23%), less foliar yellowing (16.32 PDI), low defoliation (17.00 PDI), less death of vines (12.24) and more green berry yield (0.72 kg/vine and 291.54 kg/ha projected yield). Upon comparison to the farmers' practice for the disease management by application of Bordeaux mixture (@ 1 per cent) to the affected vines after the appearance of the disease as spraying, recorded maximum leaf infection (23.29%), maximum leaf yellowing (31.97 PDI) , maximum defoliation (36.73 PDI) and more death of vine (38.76) and least green berry yield (0.60 kg per vine and 248.09 kg/ha projected yield (Table 2).

Pooled data of two years (2006-07 and 2007-08) showed that Phytophthora foot rot incidence was least on black pepper vines wherein disease incidence was minimum leaf infection (5.09 %), foliar yellowing (12.14 PDI), least defoliation (13.12 PDI), minimum death of vines (5.10 %), highest yield (1.29 kg^{-vine} green berry yield and 532.13 kg^{-ha} projected yield and highest cost benefit ratio (1:2.35) due to protection of vines to foliage and root zone with application of potassium phosphonate (@ 0.3 %) as spraying (@ 2 l^{-vine}) and drenching (@ 3 l^{-vine}) and soil application of *Trichoderma harzianum* (MTCC-5179) @ 50 g per vine with one kg of neem cake to the root zone during pre monsoon (June) and peak monsoon (August, Table 3). This was followed by application to the vine as spraying (@ 2 l^{-vine}) with 1 per cent Bordeaux mixture and drenching (@ 3 l^{-vine}) with copper oxychloride (@ 0.1 per cent a.i.) during June and August revealed leaf infection (7.01 %) foliar yellowing (16.49 PDI), low defoliation (18.49 PDI), less death of vines (8.12 %) more yield (1.23 kg^{-vine} green berry yield and 507.37 kg^{-ha} projected yield) and more cost benefit ratio (1:2.15). The above treatments were compared with the farmers practice wherein only affected vines were applied with 1per cent Bordeaux mixture to the foliage after appearance the disease. Those vines recorded highest leaf infection (21.64 %), maximum leaf yellowing (45.95 PDI) and maximum defoliation (46.69 PDI), maximum death of vines (25.38%) and lowest yield 1.03 kg^{-vine} green berry yield and 424.88 kg^{-ha} projected yield .

In the present investigation of field trial on integrated disease management of *Phytophthora* foot rot of black pepper, with various treatments or their interactions revealed a positive effect on significant reduction in disease intensity on treated vines. The present investigation results showed that crucial stages during disease development and death of vines were leaf infection, foliar yellowing, defoliation and final stage is death of vine with initiation of the disease after start of monsoon in the month of June and death of vine in late monsoon *i.e.,* in September –October. Treating the vines

Table 3 : Management of Phytophthora foot rot disease in black pepper (adaptive trial) pooled (2006-2007 and 2007-2008)

Treatments	Leaf infection (%)	Foliar yellowing (PDI)	Defoliation (PDI)	Death of vines (%)	Green berry yield (kg/vine)	Projected yield (kg/ha)**	Cost :Benefit ratio
T_1. Potassium phosphonate (0.3 %) +*Trichoderma Harzianum*+1 kg neem cake	5.09 (10.04)	12.14 (20.12)	13.12 (21.12)	5.10 (7.07)	1.29 (6.37)	532.13	1:2.35
T_2. Bordeaux mixture (1 %) spraying + Copper oxychloride (0.1 % a.i.) drenching	7.01 (12.88)	16.49 (23.70)	18.49 (25.17)	8.12 (12.59)	1.23 (6.21)	507.37	1:2.15
T_3 Farmers, practice Bordeaux mixture (1%) as spraying once after the disease appearance and only to affected vines	21.64 (26.60)	45.95 (42.54)	46.69 (43.05)	25.38 (27.77)	1.03 (5.67)	424.88	-
S.E. ±	3.01 (4.06)	4.65 (5.10)	4.49 (5.12)	3.89 (4.32)	0.13 (0.88)		
C.D. @ 5 %	8.74 (11.79)	13.51 (14.82)	13.06 (14.88)	11.30 (12.57)	0.39 (2.55)		

*arc sin transformed values **33 per cent dry age

during June and August months with fungicides and bioagents helped in reducing the inoculum levels in the soil and protected the vines from various stages on infection *viz.,* leaf infection, foliar yellowing, defoliation and death of vine.

The vines applied with combination of systemic fungicide and bioagents along with plant product neem cake, *i.e*. Potassium phosphonate as spray and drench followed by bioagents *T. harzianum* (MTCC-5179), and neem cake to the root zone as soil application combated the disease significantly and brought down leaf infection, foliar yellowing, defoliation and death of vine to the lowest level. This indicates that there may be synergistic effect of treatment combination on reducing the inoculums and triggering the protection to the vine against the disease. The present investigation on integrated disease management is practical oriented and showed that the components of IDM as eco-friendly, economically feasible and compatible. The application of neem cake + phorate + Bordeaux mixture + Akomin (Potassium phosphonate) was found effective in Phytophthora disease of pepper (Anonymous,1996). The combined application of *Trichoderma viride* + Akomin brought down incidence of black pepper wilt (Anonymous,1996). The present study on the results of integration of systemic fungicides and bio-agents were also found similar to the findings of Hegde and Anahosur (1998), Jahagirdar *et al.* (2000) and Srinivasan *et al.* (2003).

Thus, potassium phosphonate (0.3 %) as spraying and drenching with soil application of *T. harzianum* (MTCC-5179), (50 g vine^{-1}) along with neem cake (1 kg vine^{-1}) to the black pepper vines against Phytophthora foot rot served as best treatment when compared to the farmers practice with use of 1 per cent Bordeaux mixture as spray. The outcome of the present findings are best practices for protecting the black pepper vines during monsoon against the dreaded disease of the crop.

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RESEARCH ARTICLE

Effect of necrosis disease on yield and yield attributes of sunflower

■ BHARATI N. BHAT* AND D. RAJARAM REDDY

Department of Plant Pathology, College of Agriculture, Acharya N.G. Ranga Agricultural University, Rajendranagar, HYDERABAD (A.P.) INDIA

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* Corresponding author:
bharatinbhat@gmail.com

ABSTRACT

Sunflower crop is affected by necrosis disease caused by *Tobacco streak virus*, which is of recent origin. As a result of infection by sunflower necrosis disease, yield components like plant height, head diameter, number of seeds / head, 100 seed weight and seed yield /plant of the cv. Morden were adversely affected. Significant reduction in yield and yield parameters were observed in the plants affected at different severity levels of the disease (<10 per cent, 11-50 per cent and > 50 per cent) compared to healthy ones. Maximum reduction over control in seed yield was recorded at > 50 per cent severity level (63.78 per cent reduction) than < 10 per cent severity level (31.86 per cent reduction). The necrosis disease also influenced the yield contributing factors such as reduction in the size of flower head, seed setting, and test weight. The results indicated that with the increase in severity of the disease, there was corresponding decrease in yield and yield parameters of sunflower cv. Morden.

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INTRODUCTION

Sunflower (*Helianthus annuus* L.) is an important edible oilseed crop in the country next to groundnut and soybean which accounts for nearly 5 per cent of the current oilseed production. In India, the crop is cultivated in an area of 1.48 million hectares with production of 0.9 million tonnes (DOR Annual Report, 2010). The major sunflower growing states are Karnataka, Andhra Pradesh, Maharashtra and Tamil Nadu.

In India, only the association of a *Poty* and *Tospo* virus has been recorded on sunflower plants, until the emergence of a new disease called sunflower necrosis disease (SND) in recent years, which has hampered sunflower cultivation. Sunflower necrosis disease was noticed in an epidemic form consecutively for the three years (1997-99), with the incidence ranging from 10 to 80 per cent and yield loss up to 90 per cent in most of the sunflower growing regions of southern India (DOR Annual Report, 2001).

The causal agent of SND was identified as Tobacco streak virus of *Ilar* virus group (Ravi *et al.,* 2001; Bhat *et al.,* 2002a). Natural occurrence of TSV infection has also been recorded from other hosts, such as cotton, sunhemp, mungbean (Bhat *et al*., 2002b) and groundnut (Reddy *et al*., 2002).

The disease has significant impact on sunflower crop as early infection either kills the plant or causes severe stunting with malformed head or heads filled with chaffy seeds (Ravi *et al*., 2001). Early infected plants remain stunted and develop malformed heads with poor or no seed setting, resulting in complete loss of the crop (Jain *et al.,* 2003). Keeping this in view, detailed study was made on the effect of SND on yield and yield attributes in sunflower cv. Morden.

MATERIALS AND METHODS

To study, the effect of SND infection on yield and yield parameters under natural conditions, the seeds of sunflower cv. Morden were sown during 2009-10 *Kharif* season in the plots measuring 4.2 m x 3.0 m in three replications with spacing of 60 cm x 30 cm. All the recommended package of practices were followed and the plots were irrigated whenever necessary. The infected plants at different severity levels were tagged.

For each severity level, ten plants were randomly selected and tagged. Observations on plant height (cm), head diameter (cm), number of seeds/head, 100 seed weight/test weight (g) and seed yield/head (g) were recorded at harvest in randomly tagged plants. Ten healthy plants (uninfected) randomly selected from the plot served as control.

The diseased plants were tagged in each category based on the following severity level corresponding to the symptom intensity (Chander Rao *et al.,* 2003).

Disease severity level		Symptom intensity
Healthy	:	No symptoms
Less than 10 per cent	:	Systemic chlorotic spots
11-50 per cent	:	Systemic chlorotic and necrotic symptoms and stunting
More than 50 per cent	:	Severe necrosis of leaves, petiole, stem, bracts, capitulum infection and stunting

$$\text{Per cent yield loss} = \frac{Yn - Yi}{Yn} x100$$

where,

Yn = Yield of healthy plant

Yi = Yield of diseased plant

RESULTS AND DISCUSSION

There was significant reduction in plant height, head diameter, number of seeds / head, 100 seed weight (test weight) and seed yield per head in the sunflower plants affected at different severity levels over healthy ones (Table 1 and Fig.1).

Plant height :

There was significant difference between plant height of healthy and SND infected plants at different disease severity levels. The plant height was least (65.10 cm) at > 50 per cent severity level followed by 11-50 per cent (110.20 cm) and < 10 per cent (135 cm) disease severity levels compared to healthy (142.50 cm).

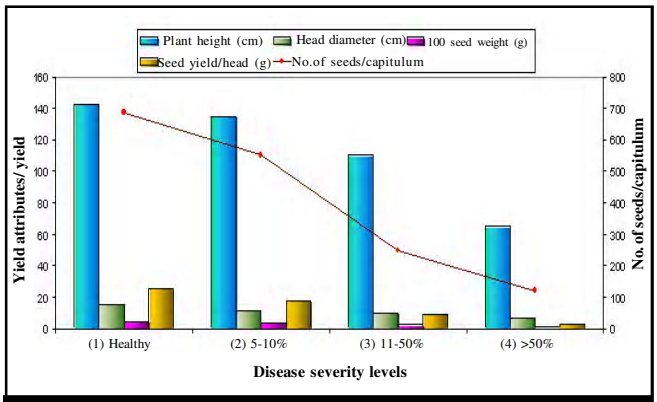

Fig. 1 : Effect of SND on yield and yield attributes of sunflower cv. Morden at different disease severity levels

Diameter of the capitulum :

Significant differences were observed in diameter of the capitulum produced by healthy and diseased plants. Head diameter was 6.60 cm at > 50 per cent disease severity level, followed by 9.85 cm and 11.40 cm in plants showing 11-50 and < 10 per cent disease severity levels, respectively compared to healthy check (15.35 cm).

Number of seeds / capitulum :

Average number of seeds / capitulum was 119.9, 247.0 and 550.4 at > 50 per cent, 11-50 per cent and > 10 per cent severity levels, respectively which were significantly lower than the healthy plants (686.10).

Test weight :

Significant differences were observed in test weight of the seeds produced by healthy and infected plants at different severity levels. At > 50 per cent severity level, the test weight was 1.11 g as against 2.21 g and 3.41 g at 11-50 per cent and > 10 per cent severity levels, respectively as against 4.45 g in healthy plants. The seeds from infected plants at different severity levels were small, discolored and chaffy compared to those seeds from healthy plants.

Seed yield / head :

Seed yield per head recorded at > 50 per cent disease

Table 1 : Effect of sunflower necrosis disease on yield and yield parameters of sunflower cv. Morden at different levels of SND severity

SND Severity level	Plant height * (cm)	Head diameter* (cm)	No. of seeds / head*	Test (100 seeds) weight* (g)	Seed yield / head* (g)	Yield reduction (%) over healthy
<10 %	135.00	11.40	550.40	3.41	17.38	31.86
11-50 %	110.20	9.85	247.00	2.21	9.24	63.78
> 50 %	65.10	6.60	119.90	1.11	2.75	89.22
Healthy	142.50	15.35	686.10	4.45	25.51	
S.E. ±	1.18	0.21	4.34	0.093	0.33	
C.D. (0.05)	3.43	0.62	12.59	0.27	0.96	

* Mean of 10 plants

severity level was significantly lower (2.75 g/head) as compared to 11-50 per cent and < 10 per cent severity levels (9.24 g and 17.38 g, respectively); whereas, healthy ones recorded 25.51 g/head. Highly significant differences were observed between seed yield of healthy and diseased plants at different severity levels. Maximum (89.22 per cent) reduction in seed yield over healthy plants was observed in infected plants at > 50 per cent disease severity level followed by 63.78 per cent and 31.86 per cent reduction at 11-50 per cent and < 10 per cent disease severity levels, respectively.

The results indicated that with the increase in severity of the disease (SND), there was corresponding decrease in yield and yield attributes of sunflower cv. Morden. Further, the necrosis disease also influenced the yield contributing factors by mainly reducing the size of flower heads, seed setting and seed weight. The reduction in plant height as a result of SND infection is one of the factors leading to reduced synthesis of food materials and also depends on the stage of infection and cultivar. The effect was more when plants were infected early as compared to those infected later. The results also suggest that it is very important to initiate plant protection measures, right from the initial crop growth stages to manage thrips vector as well as the causal virus.

The results are in accordance with DOR Report (2000) and Chander Rao *et al.* (2003) who reported that all the growth and yield parameters were significantly affected due to SND resulting in yield loss of 89 per cent at > 50 per cent disease severity level, 63 per cent and 20 per cent at 11-50 per cent and < 10 per cent disease severity levels, respectively. Chandra Mohan (2004) also reported that SND infection in sunflower caused significant reductions in plant height (58.99 per cent), head diameter (64.48 per cent), number of seeds per head (91.07 per cent), seed filling per cent (62.20 per cent), seed yield per plant (96.72 per cent), test weight (59.57 per cent) and oil content (50.97 per cent) compared to healthy plants.

It can be concluded that disease severity had definite effect on yield and yield attributes of sunflower cv. Morden. With the increase in disease severity, there was corresponding decrease in yield and yield attributes.

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RESEARCH ARTICLE

Compatibility of certain biopesticides Azadirachtin formulations and sodium bicarbonate with *Trichoderma harzianum* (Th-43)

■ CHANDRA PRABHA BHANDARI* AND J. KUMAR

Department of Plant Pathology, Centre of Advance Faculty Training, G.B. Pant University of Agriculture and Technology, Pantnagar, U.S. NAGAR (UTTARAKHAND) INDIA

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ABSTRACT

The sharp increase in the use of chemical pesticides in India in recent years has resulted in severe implications in the development of pesticidal resistance in key pest species, pesticidal residues in food chain and degradation in the quality of eco-system and human health. It is therefore, important to identify alternatives to chemical pesticide in plant protection without sacrificing the productivity and profitability of agriculture. Among various non-chemical options (host plant resistance, cultural, biological and integrated pest management), biopesticides which are target specific, eco-friendly and biodegradable are potential alternatives to chemical pesticides and are known to exhibit antifungal activities against certain plant pathogenic fungi. In the present investigation, studies were conducted to evaluate *Azadirachtin* formulations (Soluneem , Mycostat) and Sodium bicarbonate for their compatibility with bioagents in order to increase their action spectrum. *Trichoderma harzianum* (Th-43) showed some degree of compatibility with Mycostat at lower concentrations (1000-4000 ppm) but was incompatible at higher concentrations (6000 ppm). The bioagent showed relatively less sensitivity with Soluneem and Sodium bicarbonate thus, could be considered compatible by showing an additive effect. The present result will help to delineate the possibility of combining *Trichoderma harzianum* (Th-43) biocontrol agent and biopesticides for use in an integrated pest management.

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* Corresponding author:
chandraprabha_bhandari@rediffmail.com

INTRODUCTION

The present agricultural scenario signifies the importance of IPM strategies in crop protection. The long term exposure and high dose of fungicides have led to development of resistant strains in several fungal pathogens. From all angles efficiency, feasibility, economy and environmental sustainability, biocontrol of plant pathogens is one of the best management options available (Bagwan, 2003). Species of *Trichoderma* are common soil saprophytic hyphomycetes found in all climates throughout the world. Members of this genus have been studied as antagonists in biocontrol systems against various plant pathogens. These fungi are very effective as biocontrol agents because their powerful extracellular lytic enzymes produce necrotrophic action on fungi through lysis of cell walls (Bacon *et al*., 2001). *Trichoderma* is one of the most potent biocontrol agents used now a day's majority for seed and soil treatment due to its efficient antagonistic activity against various soil borne micro flora. Application of concerned antagonist is easy, economically feasible, save time and money besides reducing the amount of agrochemicals required to control a disease at field level both at pre-and post-infection stages (Kumar *et al.,* 2005). Therefore, a biological agent besides being effective should be compatible with the latest crop production practices including pesticides use. Reports on the greater tolerance of

Trichoderma spp. to broad spectrum biopesticides are also available (Lal and Maharshi, 2007).

Keeping the above view in mind, a laboratory study was carried out to assess the compatibility of *Trichoderma harzianum* (Th-43) with different doses of biopesticides.

MATERIALS AND METHODS

The fungal antagonist, *Trichoderma harzianum* (Th-43) taken from bio control laboratory of Department of Plant Pathology, GBPUA and T., Pantnagar was used in the present study. The sensivity of biocontrol agent against biopesticides was examined by poison food technique.

Double strength solution of each biopesticide was prepared in sterilized distilled water in 250 ml Erlenmeyer flask containing same amount of sterilized molted double strength PDA so as to get final concentration of biopesticides. The medium containing different concentrations of biopesticides was poured into sterilized petriplates and allow to solidify. Each Petriplate was centrally inoculated with 5 mm mycelial disc cut with the help of sterilized cork borer from 48 hrs old culture of fungal biocontrol agent and unamended PDA plates served as check. Three replications were maintained for each treatment and incubated at 26±1^{0}C. Regular observations were recorded and finally the colony diameter was measured when the check plates were fully covered with mycelial growth of test fungus.

Per cent inhibition of growth was calculated as follows :

$$I = (C - T/C) x100$$

where,

I = Per cent inhibition

C = Radial growth in check (cm)

T= Radial growth in treated plates (cm)

RESULTS AND DISCUSSION

The experimental findings of the present study have been presented in the following sub heads:

Compatibility of Azadirachtin formulation, Mycostat with *Trichoderma harzianum* (Th-43) :

Effect of mycostat on radial growth of *Trichoderma harzianum* (Th-43) was evaluated under *in vitro* condition using poisoned food method. The results are given in (Table1 and Fig.1). Mycostat was evaluated at ten different concentrations (*viz.,* 1000, 2000, 3000, 4000, 5000, 6000, 6500, 7000, 7500 and 8000 ppm) against *Trichoderma harzianum* (Th-43) and it was found that Mycostat significantly inhibited the growth of *Trichoderma harzianum* (Th-43) at all the concentrations. Mycostat checked the growth completely at higher concentration (6000 ppm) but it allowed the biocontrol agent to grow at lower concentrations (1000-4000 ppm). *Trichoderma harzianum* (Th-43) showed some degree of compatibility with Mycostat at lower concentrations but was found to be totally incompatible at higher concentrations.

Table 1 : Compatibility of *Trichoderma harzianum* (Th-43) with Azadirachtin formulation, Mycostat

Sr. No.	Biopesticide concentration (ppm)	Per cent inhibition at different concentrations of Mycostat after full growth in control	
		Growth (cm)	% Inhibition
1.	1000	4.18	53.51 (47.01)
2.	2000	1.86	79.25 (62.91)
3.	3000	1.45	83.84 (66.29)
4.	4000	1.33	85.18 (67.36)
5.	5000	1.03	88.51 (70.19)
6.	6000	-	100 (90)
7.	6500	-	100 (90)
8.	7000	-	100 (90)
9.	7500	-	100 (90)
10.	8000	-	100 (90)
C.D. (P = 0.05)			1.023
CV (%)			0.786

* Values in parenthesis are in angular transformation

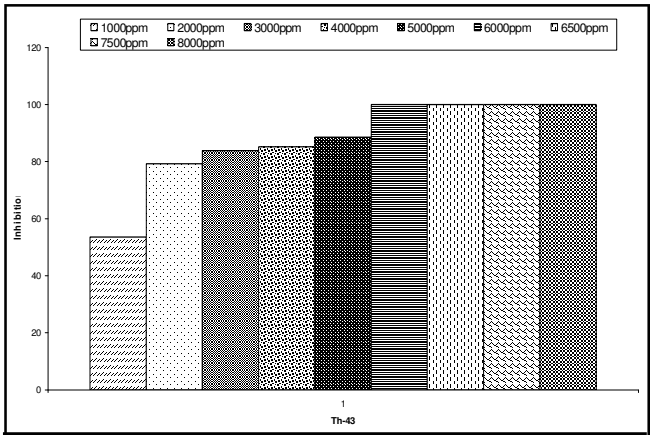

Fig. 1 : Compatibility of Azadirachtin formulation, Mycostat with *Trichoderma harzianum* (Th-43)

Compatibility of Azadirachtin formulation Soluneem with *Trichoderma harzianum* (Th-43) :

Azadirachtin formulation, Soluneem was evaluated at six different concentrations *viz.,* (100, 200, 300, 400, 500 and 600 ppm, against *Trichoderma harzianum* (Th-43) by poisoned food technique. Results are given in (Table 2 and Fig. 2).

It was observed that Soluneem favoured the growth of *Trichoderma harzianum* at all concentrations tested suggesting that Soluneem was less effective in inhibiting the radial growth of fungal biocontrol agent at all the concentrations. Thus, *Trichoderma harzianum* (Th-43)

showed relatively less sensitivity to Soluneem and could be considered compatible with Soluneem.

Table 2 : Compatibility of *Trichoderma harzianum* (Th-43) with Azadirachtin formulation, Soluneem

Sr. No.	Biopesticide concentration (ppm)	Per cent inhibition at different concentrations of Soluneem after full growth in control	
		Growth (cm)	% Inhibition
1.	100	8.26	8.14 (16.46)
2.	200	7.53	16.29 (23.75)
3.	300	7.15	20.55 (26.95)
4.	400	7	22.14 (28.06)
5.	500	6.06	32.59 (34.81)
6.	600	5.5	38.88 (38.57)
C.D. (P = 0.05)			2.807
CV (%)			3.35

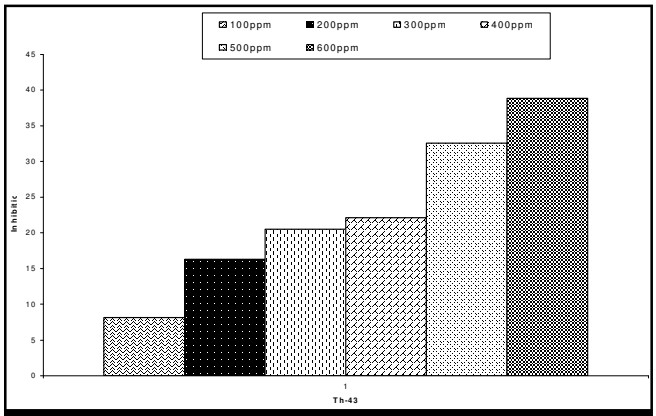

Fig. 2 : Compatibility of Azadirachtin formulation, Soluneem with *Trichoderma harzianum* (Th-43)

Table 3: Compatibility of *Trichoderma harzianum* (Th-43) with Sodium bi carbonate

Sr. No.	Biopesticide concentration (ppm)	Per cent inhibition at different concentrations of Sodium bi carbonate after full growth in control	
		Growth (cm)	% Inhibition
1.	100	6.78	24.62 (29.75)
2.	250	5.39	40.03 (39.25)
3.	500	4.08	54.62 (47.65)
4.	1000	2.2	75.55 (60.36)
5.	1500	2.1	76.58 (61.06)
6.	2000	1.77	80.29 (63.64)
7.	2500	1.51	83.14 (65.75)
8.	3000	1.43	84.07 (66.47)
9.	3500	1.1	87.77 (69.56)
10.	4000	0.78	91.29 (72.88)
C.D. (P = 0.05)			1.27
CV (%)			1.30

* Values in parenthesis are in angular transformation

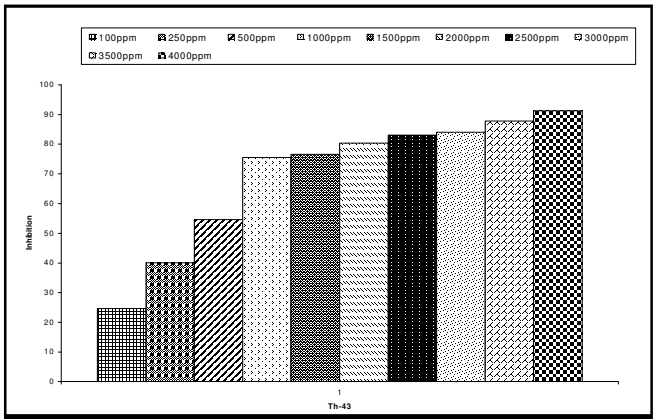

Fig. 3 : Compatibility of sodium bicarbonate with *Trichoderma harzianum* (Th-43)

Compatibility of Sodium bicarbonate with *Trichoderma harzianum* (Th-43) :

Sodium bicarbonate was evaluated at ten different concentrations (100, 250, 500, 1000, 1500, 2000, 2500, 3000, 3500, 4000 ppm) against *Trichoderma harzianum* (Th-43). Results are given in (Table 3 and Fig. 3).

It was found that at all the concentrations tested *i.e.*, 100, 250, 500, 1000, 1500, 2000, 2500, 3000, 3500, 4000 ppm of Sodium bi carbonate was found less effective in inhibiting mycelial growth of *Trichoderma harzianum* (Th-43) and thus can be considered compatible with *Trichoderma harzianum* (Th-43). One of the most desirable characteristics of a biocontrol agent is its insensitivity to the biopesticides which are effective against the test pathogen. Unless and until the biocontrol agents are insensitive to the biopesticides, they cannot be integrated successfully with biopesticides for the purpose of plant disease control.

The results on sensitivity of biopesticides against *Trichoderma* sp. revealed that Multineem at lower concentration favoured the growth of fungus *Trichoderma viride* (Bhatnagar, 2004). Singh and Singh (2007) found that Bavistin checked the growth completely at all concentrations followed by Captan and Vitavax. Monocrotophos was least effective pesticide inhibiting the growth of *Trichoderma viride*-1 and *Trichoderma viride*-2 at all the concentrations. It showed that *Trichoderma viride*-1 and *Trichoderma viride*-2 were compatibile with monocrotophos and less compatibile with Captan and Vitavax and non-compatibile with Bavistin.

Singh and Singh (2003) recorded best compatibility of *Trichoderma harzianum* with Captan and monocrotophos at all the concentrations and moderate compatibility with Vitavax**.** Gupta (2004) recorded that Bavistin was completely

incompatible with *Trichoderma harzianum,* while Captan and monocrotophos showed highest compatibility at 1000 ppm concentration. Abd- EI-Moity *et al.* (1982) observed that while Benomyl was found to be strongly inhibitory to *Trichoderma* in culture even at 0.5 mg/ml, Captan and PCNB were not inhibitory to *Trichoderm*a spp.

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IJPP

RESEARCH ARTICLE

Biodiversity of tachinid flies (Diptera : Tachinidae) from Western Maharashtra

■ T. V. SATHE

Department of Zoology, Shivaji University, KOLHAPUR (M.S.) INDIA

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*Corresponding author:
drtvsathe@rediffmail.com

ABSTRACT

Tachinid flies (Diptera : Tachidae) are potential biocontrol agents of insect pests. Therefore, biodiversity of Tachinid flies have been studied from Western Ghats and plain region of Western Maharashtra. In all, 20 species of Tachinids have been recorded attacking various lepidopterious pests *viz., Helicoverpa armigera* (Hubn.), *Spodoptera litura* Fab., *Spodoptera exigua* Fab., *Achea janata* (Linn.), *Tarache tobabilis* Walk., *Anomis* sp., *Chilo* spp., *Sesamia inferens,* silkworms, etc. with a very high per cent parasitism.

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INTRODUCTION

Tachinid flies (Diptera : Tachinidae) are potential biocontrol agents of lepidopterous pests. However some species attack useful insects like mulberry and wild silkworms. Therefore, biodiversity of tachinids have been studied from Western Maharashtra. Western Maharashtra is admixture of forest (Western Ghats) and agricultural crops (plane region). Insects cause severe damage to both forest and plane region crops and difficult to control with insecticides. Secondly insecticides lead serious problems such as pollution, health hazards, killing of beneficial organisms, pest resistance, pest resurgence, secondary pest out break etc. Hence, survey, conservation, protection and utilization of natural enemies against pest insects is the need of the day. Keeping in view all above facts the present work was carried out. Review of literature indicates that Thomson (1944), Patel (1980), Natrajan and Sundaramurthy (1990), Carl (1976), etc. worked on the diversity of tachinid parasitoids of insect pests.

MATERIALS AND METHODS

During the survey of Ichneumonid parasitoids, during 2008 to 2012 under UGC Project No. 37/334/2009 (12), a huge number of lepidopterous caterpillars were collected. Along with the Ichneumonids, some tachinids have also been found emerged from pest caterpillars. Later, the tachinids have been identified by consulting appropriate literature (Thompson, 1944; Crosskey, 1976). The survey of parasitoids was conducted at different study spots in district Kolhapur, Satara and Pune at 15 days interval by adopting 1 man 1 hr collection of caterpillars from both forest and agro-ecosystems including Western Ghats. The collected caterpillars were reared on the respective food plants in the laboratory (25±1°C, 70-75% RH and 12 hr photoperiod) for screening tachinid parasitoids.

RESULTS AND DISCUSSION

Results recorded in Table 1 indicate that in Western Maharashtra, tachinids attacked both pests and useful insects such as silkworms. Thus, tachinids acts as both biocontrol agent for agricultural and forest insect pests and pests for various silk worm species. The highest per cent parasitism (64%) was noted on mulberry silk worm *Bombyx mori* L. by uzifly *Exorista bombycis* (Louis) and lowest (1.5%) by *Podomyia setosa* Dol on *Parnara mathias* Fab. from forest ecosystem.

E. bombycis, E. sorbillans, B. zebina and *C. pavida* were dominant on silkworm species. However, on pest insects,

Table 1 : Biodiversity of Tachinids from Western Maharashtra

Sr. No.	Parasitoid name	Host name	Per cent parasi-tism	Occurrence forest/ agro-ecosystem
1.	*Actia monticola* Tams	*Tarache notabilis* Walk.	13	Agro-
		Eutectona machearalis (Walk.)	8	Forest
		Hublaea puera Cramer	4	Forest
2.	*Afrovoria indica* Mesnil	*Helicoverpa armigera* (Hubner)	5	Agro-
3.	*Blepharella lateralis* Macq.	*Spodoptera litura* (Fab.)	13	Agro-
4.	*Blepharella setigera* Certi.	*S. litura*	7	Agro-
		S. litura	5	Forest
5.	*Blepharipha zebina* Walker	*Bombyx mori* L.	23	Forest
		Antheraea mylitta D.	20	Agro-
		A. militta	2.5	Forest
		Cricula trifenestrata Helfer	13	Agro-
6.	*Carcelia buitenz orgensis* Baranoff	*Achea janata (*Linn.)	13	Agro-
7.	*C. kockiana* Townsend	*A. janata*	3	Agro-
		Lymantria sp.	2	Forest
8.	*Drino imberbis* Weid	*H. armigera*	9.5	Agro-
9.	*Exorista fallax* Mg	*H. armigera*	22	Agro-
10.	*Exorista mobycis* (Louis)	*B. mori*	64	Agro-
		A. mylitta	32	Forest
		H. armigera	18	Agro-
		Adisura atkinsoni	5	Agro-
11.	*Exorista sorbillan* (Weid)	*B. mori*	62	Agro-
		A. mylitta	36	Forest
		Actias selene	23	Agro-
		H. armigera	5	Agro-
12.	*Exorista siviloides* Bar.	*T. notabilis*	17	Agro-
		E. machearalis	2.5	Forest
13.	*Goniophthalmus halli* Mesnil	*H. armigera*	12	Agro-
			3.5	Forest
14,	*Ctenophorocera pavida* (Meigen)	*B. mori*	42	Agro-
		S. litura	3	Agro-
15.	*Halidya luteicornis* Walker	*A. janata*	2	Agro-
16.	*Isomeria cinerasnous* Rondani	*H. armigera*	7	Agro-
17.	*Podomyia setosa* Dol	*Parnara mathias* (Fab.)	4	Agro-
		A. janata	1.5	Agro-
		Melantis ishmene	2.5	Forest
18.	*Sturmiopsis inferens* Townsend	*Chilo partellus* (Swin.) *Chilo* sp.	2.5	Agro-
		Chilo infuscatellus (Snellen)	2.0	Agro-
		Sesamia inferens (Walker)	6	Agro-
19.	*S. samiberbis* Bezzi	*C. infuscatellus*	3	Agro-
20.	*Drino* sp.	*Spodoptera exigna*	3	Agro-

although attacked by several tachinid flies, the percentage of parasitism was comparatively low than on silkworm species, showing more affinity towards silkworms.

Narayanaswamy *et al*. (1993) studied ovipositional preferences of *E. bombycis* towards some lepidopteran insects. They noted that the uzifly mostly preferred *B. mori* larve (54.52%) followed by *Samia cynthia ricini* (13.22%). *A. mylitta* (10.00%), *S. litura* (8.91%), *H. armigera* (7.41%), *A. janata* (5.16%) and *A. atkinsoni* (0.86%). They also tried *Corcera cephalonica* larvae but, no development was noted on these larvae. Similarly, *E. sorbillans* parasitized almost all silkworm species found in India. *B. zebina* was the most injurious parasitoid of non-mulberry silk worms. It caused 80.00 per cent damage to muga silkworms *A. assama* (Goswami and Barah, 1989) and also to *C. tritenestrata* on large extent. Control of uziflies is great challenge to sericulturist. However, tachinids play a very important role in control of insect pests from agroecosystems. According to Nagarkatti (1981) dipterous parasitoids have good potential in control of *H. armigera* in India. Rearing methods for a tachinid fly *Carcelia illota* (Curran) have been developed by Patel *et al*. (1970). Similarly, mass rearing technique has been developed for *Goniophthalmus* halli Mesn (Patel and Singh, 1972). The tachinid *Peribaea orbata* (Wied.) can also be mass reared easily in the laboratory. This parasitoid is effective against *S. litura* and *H. armigera*. However, it seems that mass rearing of solitary parasitoids is laborious and uneconomical since the parasitized larvae have cannibalism. As pesticides never solve the permanent problem of pest control, and lead several serious problems, the biocontrol agents like tachinids should be surveyed, conserved and utilized for pest control.

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IJPP

RESEARCH ARTICLE

Exploiting the extract of medicinal plants for the management of grapevine powdery mildew

■ E. RAJESWARI

Department of Plant Pathology, Tamil Nadu Agricultural University, COIMBATORE (T.N.) INDIA

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Author for correspondence :

ABSTRACT

Extract of fifteen medicinal plants were screened for their antifungal activity against grapevine powdery mildew caused by *Uncinula necator*. The results of the *in vitro* study revealed that, the neem seed kernel extract (NSKE) 5 per cent recorded the highest germination inhibition of 72.02 per cent. This was followed by leaf extract of *Ocimum sanctum*(10%), rhizome extract of *Curcuma longa* (5 %) and leaf extract of *Catharanthus roseus* (10 %) which inhibited the conidial germination by 69.1, 65.9 and 64.2 per cent, respectively. The results of the field experiment showed that two rounds of spraying with NSKE (5 %), first spray immediately after the appearance of the disease and second at 15 days intervals effectively reduced the powdery mildew (62.24% disease reduction) disease incidence.

How to view point the article : Rajeswari, E. (2012). Exploiting the extract of medicinal plants for the management of grapevine powdery mildew. *Internat. J. Plant Protec.*, **5**(2) : 371-374.

INTRODUCTION

Medicinal plants are the excellent source of antimicrobial agents which posses antifungal, antibacterial and antiviral properties. Plant generally produces many secondary metabolites which constitute important sources of micro biocides. The search for antimicrobial activity of medicinal plants against plant pathogen is highly essential because green plants are safer than costly synthetic fungicides. The objective of present study was to investigate the antifungal activity of traditionally used medicinal plant extracts against grapevine powdery mildew disease caused by *Uncinula necator*. Grapevine powdery mildew causes up to 50 per cent losses in South India (Sohi, 1983). Powdery mildew affected berries are cracked there by providing entry sites for *Botrytis cinerea* and sour rot organism (Sall *et al*.,1981).Powdery mildew fungi infection resulted in reduced average bunch and berry size and weight(Thind *et al*., 1998). Most of the grapevine growers use fungicides for the management of powdery mildew which have many adverse side effects. To overcome all the ill effects caused by the synthetic fungicides and to evolve eco-friendly management strategy for grapevine powdery mildew, the present study was undertaken.

MATERIALS AND METHODS

***Preparation of plant extracts* :**

Extract of fifteen medicinal plants were screened for their antifungal activity against *U. necator in vitro*. Freshly collected plant material (leaf, seed rhizome and root) were separately washed with tap water and then with alcohol and finally with repeated changes of sterile distilled water. These were separately grounded in sterile distilled water (1 ml/ g of the tissue) using a pestle and mortar. The extract was strained through two layers of muslin cloth. Subsequently filtered through Whatman No.1 filter paper and finally passed through Seitz filter to eliminate bacterial contamination. This formed standard plant extract solution (100 %). This was further diluted to the required concentration with sterile distilled water. All the leaf extracts were used at 10 per cent concentration while seed and rhizome extracts were used at five per cent concentration.

***In vitro* efficacy of medicinal plant extracts against *U. necator*:**

The efficacy of plant extracts against conidial germination of *U. necator* was assessed by detached leaf technique (Varalakshmi *et al*., 1999). Grapevine leaves were washed in sterile distilled water and air dried. Plant extract of each of the medicinal plants was placed individually on the ad adaxial surface of the leaf, the droplets were evenly spread with a fine camel hair brush and allowed to air dry. The treated leaves were inoculated with the conidia of *U.necator* (3 x 10^4 conidia/ ml). The leaves sprayed with the conidial suspension alone served as the control. Three leaves from each treatment were transferred to a Petri dish with their petioles dipped in water and incubated at 20 °C. Each treatment replicated thrice. After 72 h, the leaves were observed with microscope equipped with fine light arrangement for conidial germination. The total and germinated conidia were counted in three microscopic fields and per cent inhibition of conidial germination was worked out.

Efficacy of plant extracts against grapevine powdery mildew in pot culture under artificial inoculation :

Six plant extracts (seer/kernel/rhizome) which were found effective against U.necator in vitro were tested for their efficiency against powdery mildew in pot culture under artificial inoculation. The treatments consisted of T_1- Catharanthus roseus (leaf extract - 10%), T_2-Curcuma longa (rhizome extract-5%) ,T_3- (Datura stramonium leaf extract-10%),T_4- Neem seed kernel extract (NSKE) (5%), T_5- Ocimum sanctum (leaf extract 10%), T_6- Vitex negundo (leaf extract,10%), T_7- Wettable sulphur (0.4%), T_8 - Control. The highly susceptible Thompson seedless, grapevine stem cuttings were raised in pots and maintained in glass house by regular, uniform and judicious watering. The 120 d old plants were inoculated with the conidial suspension (3x10 4 conidial/ ml) of *U. necator*. Necessary water congestion was given both 24 h prior to and after inoculation for maintaining saturated humid condition. After 24 h of inoculation, the above mentioned treatments were imposed by spraying. The wettable sulphur (0.4%) was used as the chemical control .The plant sprayed only with *U.necator* served as the control. The intensity of the disease was recorded 15 d later using score chart developed d by Singh *et al*. (1994). The results were expressed as perc ent disease reduction.

Efficacy plant extracts against grapevine powdery mildew in the field :

Based on the results obtained on the efficacy of plant extracts in pot culture, two promising medicinal plant extracts were selected and tested in the field. Field experiment was conducted with four treatments and five replications in Randomized Block Design to evaluate their efficacy against grapevine powdery mildew. The treatments comprised of T_1 – *C. roseus* (leaf extract, 10%) ,T_2-Neem seed kernel extract (5%), T_3- Wettable sulphur (0.4%) and T_4- Control. Spraying was given with all the above treatments on grapevine plants one month after pruning and immediately after the appearance of disease symptoms. Fifteen days after first spraying second spraying was given with all the treatments observation and disease incidence was recorded 15 d after second spraying by score chart already mentioned. Fruit yield was also recorded for all the treatments.

RESULTS AND DISCUSSION

Among the 15 plant extracts tested, NSKE (5%) recorded the minimum conidial germination of 24.75 per cent as against 88.4 per cent in the control, which accounted for the germination inhibition of 72.02 per cent (Table 1). The antifungal activity of neem products (azadiractchtin, nimbin , nimbidin) has been reported by several workers (Schmutterer, 1995) Govindachari *et al.,* 1998).The formulated product *viz.,* neemazal containing 62.5 PPM azadirachtin effectively reduced the conidial germination of *Sphaerotheca fuligena* on cucumber (Conventry and Allen 2001. Next to NSKE (5%) leaf extracts *O. sanctum* (10%), rhizome extract of *C.longa* (5%) and leaf extract of *C.roseus* (10%) were found to be effective which reduced the conidial germination by 69.10, 65.90 and 64.23 per cent, respectively. The leaf extract of *Aloe vera* (10%) gave highest conidial germination of 68.34 per cent and lowest germination inhibition of 22.72 per cent (Table 1).

Post inoculation (artificial) spraying of NSKE (5%) was significantly superior in reducing the disease incidence by recording only 36.86 per cent and with 60.21 per cent disease reduction as against 70.4 per cent in the control. Leaf extract of *C. roseus* and *O. sanctum* (10%) reduced the disease incidence by 40.50 and 42.2 per cent, respectively (Table 2). The neem products gave good control of powdery mildew infection on grapevine leaves, shoots and berries (Rey and Schlosser, 1994). Neem derivatives displayed several remarkable qualities because of the presence of array of highly sensitive chemicals *viz.*, azadiractin, meliantriol salanin, nimbidin and nimbicidin.

Two sprays of NSKE (5%) given on grapevine plants first spray, just at the appearance of disease and second at 15 d later effectively reduced (62.24%) the powdery mildew in the field. The same treatment recorded fruit yield of 11.81 t/ha as against 8.5 t/ha in control (Table 3). Neem seed kernel extract has low mammalian toxicity and relatively safe to non-target organisms. Consequently the use of neem based product is gaining acceptability as a novel environmentally sound product in both developing and industrial countries. Therefore, spraying NSKE (5%) is the effective eco-friendly method for the management of grapevine powdery mildew.

Table 1: *In vitro* assay of medicinal plant extract against conidial germination of grapevine powdery mildew pathogen *U.necator*

	Medicinal plant extract		*U.necator*	
Sr.No.	Common name	Botanical name	Conidial germination*	Germination inhibition (%)
1.	Vasambu(LE)	*Acorus calamus*	44.73(41.98)	49.44
2.	Adathodai (LE)	*Adhatoda vasica*	56.03(48.47)	36.67
3.	Vilvam(LE)	*Aegle marmelos*	60.63(51.15)	31.47
4.	Sothukathazhai (LE)	*Aloe vera*	68.34(55.79)	22.72
5.	Sitharathai (LE)	*Alpinia galanga*	36.33(37.07)	58.94
6.	Aduthinnapalai (LE)	*Arisolochia bracteolata*	53.27 (46.88)	39.79
7.	Neem(Seed kernel)	*Azadirachta indica*	24.75(29.80)	72.02
8.	Periwinkle (LE)	*Catharanthus roseus*	31.65(34.24)	64.23
7.	Vallarai (LE)	*Centella asiatica*	63.35(52.75)	28.39
8.	Omavalli (LE)	*Coleus aromaticus*	38.75(38.50)	56.20
9.	Turmeric(Rhizome)	*Curcuma longa*	30.17(33.30)	65.90
10.	Umathai (LE)	*Datura stramonium*	33.97(35.65)	61.60
11.	Thulasi (LE)	*Ocimum sanctum*	27.34(31.52)	69.10
12.	Keezhanelli (LE)	*Phyllanthus amarus*	35.73(36.71)	59.61
13.	Siriyanangai (LE)	*Polygala grinersis*	54.03(47.31)	38.92
14.	Notchi (LE)	*Vitex negundo*	33.55(35.40)	62.34
15.	Amukara (root)	*Withania somnifera*	40.07(39.27)	54.70
	C.D.(P = 0.05)		1.44	

LE- Leaf extract at 10 per cent Seed kernel, rhizome, root extract at 5 per cent
* Mean of three replications. Data in parentheses represent arc sine transformed values

Table 2 : Efficacy of medicinal plant extract against grapevine powdery mildew disease in pot culture under artificial inoculation

Sr. No.	Treatments	Per cent disease index (PDI)*	Disease reduction (%)
1.	*C. roseus* (LE 10%)	42.17(40.50)	53.17
2.	*C. longa* (rhizome extract 5%}	50.63(45.36)	44.01
3.	*D. stramonium* (LE 10%)	53.87(47.22)	40.43
4.	Neem seed kernel extract (5%)	35.98(36.86)	60.21
5.	*O. sanctum* (LE 10%)	45.07(42.2)	50.16
6.	*V. negundo* (LE 10%)	45.98(42.70)	49.15
7.	Wettable sulphur (0.4%)	21.67(27.74)	76.04
8.	Control	90.43(70.04)	
	C.D.(P= 0.05)	1.40	

LE- Leaf extract at 10 per cent * Mean of three replications Data in parentheses represent arc sine transformed values

Table 3 : Efficacy of medicinal plant extract against grapevine powdery mildew disease in the field

Sr. No.	Treatments	Per cent disease index (PDI)*	Disease reduction (%)	Yield t/ ha
1.	*C. roseus* (LE 10%)	41.37(40.03)	47.27	10.12
2.	Neem seed kernel extract (5%)	29.62(32.97)	62.24	11.81
3.	Wettable sulphur (0.4%)	21.46(27.29)	72.64	
4.	Control	78.45(62.34)	-	
	C.D.(P= 0.05)	2.55		0.57

* Mean of five replications LE- Leaf extract at 10 per cent Data in parentheses represent arc sine transformed values

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RESEARCH ARTICLE

Status of Karnal bunt of wheat in Jammu division (J&K)

■ B. SINGH[1*], C. S. KALHA[2] V. K. RAZDAN[2] A. VAID[3] AND S.K.SINGH[4]

[1*]Regional Horticulture Research Sub Station, (SKAUST, J) Bhaderwah, DODA (J&K) INDIA
[2]Department of Plant Pathology, University of Agricultural Sciences and Technology, (J) Chatha, JAMMU (J&K) INDIA
[3]Krishi Vigyan Kendra, (SKAUST, J) Kathua, JAMMU (J&K) INDIA
[4]Pulses Research Sub Station, (SKAUST, J) SAMBA (J&K) INDIA

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* Corresponding author:
brajeshbhau@yahoo.co.in

ABSTRACT

It has been observed that numerous factors like varietal reshuffle, intensive cultivation and high input technology are responsible for minor diseases to become major production constraint. One such disease that has caused much concern is Karnal bunt of wheat caused by *Neovossia indica* (Mitra) Mundkur. The disease was observed in all the districts surveyed in Jammu division. Highest disease incidence was recorded in Rajouri and Udhampur (1.66%), followed by Kathua (1.58%), Doda (1.41), Jammu (1.28%) and least in Poonch (0.90%). Teliospores of the fungus were isolated from the infected seed samples collected from areas surveyed. Soil samples were collected from all location surveyed. Area wise count of teliospores in soil provided the evidence that Poonch (7.5) followed by Rajouri (7.0) and Udhampur (6.5) were hot spots and Doda (1.5) was found to be least having teliospores in. Jammu soils which recorded only 2.0.

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INTRODUCTION

Wheat (*Triticum* sp.) known in Neolithic times is one of the foundation crops of India's agriculture. India occupies third position in the world in production of wheat. Various factors like varietal reshuffle, intensive cultivation and high input technology are designated to be responsible for minor diseases to become major production constraint.

One such disease that has caused much concern is Karnal bunt of wheat caused by *Neovossia indica* (Mitra) Mundkur. This disease was first reported from Karnal district of Haryana (India) in 1930s and was subsequently found in Pakistan, Afghanistan, Mexico and Nepal (Singh *et al*., 1989).This disease is widely prevalent in all the wheat growing areas in North-Western India. During severe epidemics, total losses in India have been around 0.3 to 0.5 per cent with incidence as high as 89 per cent in some fields (Joshi *et al*., 1983)

Karnal bunt of wheat also known as ' partial bunt' is of great significance not only because it causes reduction in yield and quality of grain, but has proved a major setback in capturing the international wheat market due to strict quarantine and tolerance limit put to zero level by some countries (Agarwal *et al*., 1993). Karnal bunt of wheat has become a serious threat to around 16-19 per cent of the world wheat, traded annually between countries. Karnal bunt usually affects only a few spikelets within a wheat spike. In addition, the pathogen usually causes a partial bunt with teliospores replacing only a portion of the kernel. Yield losses in the Punjab and Jammu regions of India were estimated at 0.2 per cent during 1969–1970 (Munjal, 1975; Wareham , 1986). Even during the worst years of 'epidemic', the damage to wheat crops was reported as only 0.2– 0.5 per cent of total production in infested areas (Joshi *et al*.1983). Losses of 0.3–0.5 per cent have been assessed during the most severe years between 1982 and 1989 particularly in Uttar Pradesh (Singh, 1994; 2005). Many reports

of high losses emanate from the mid- to late-1970s when susceptible wheat cultivars were grown (Wareham, 1986).

MATERIALS AND METHODS

The present investigations were undertaken at Faculty of Agriculture, Division of Plant Pathology, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu and Indian Agricultural Research Institute, New Delhi during 2005-08. Studies on Karnal bunt were based on laboratory and field experiments.

Collection of wheat seed samples to assess the status of Karnal bunt in Jammu division :

Wheat seeds were collected from various wheat growing areas, covering all the six districts falling within Jammu division during 2006-07 and 2007-08. During disease surveys for Karnal bunt, wheat grain samples were collected from threshing floors and various godowns located throughout Jammu division .Field samples not less then 250 g were generally collected, covering all six districts, falling in Jammu division. The working sample of approximately 2500 to 3000 grains was obtained by division and re division of the 250 g seed lot. Out of this working sample, 1000 grains were taken and infected seeds were sorted to calculate the percentage of infection. From each district, ten samples each were taken up to assess the status of Karnal bunt in Jammu division. Same methodology was adopted in subsequent surveys too. Infection percentage was calculated using formula :

$$\frac{\text{Total infected grains}}{\text{1000 grains}} \text{x100} = \text{Infection percentage}$$

Collection of soil samples to assess the status of Karnal bunt in Jammu division :

Teliospores of caustive agent of Karnal bunt enter the soil at the time of harvest, threshing or winnowing or may be as external seed contaminant. Teliospores act as potential inoculum load for next crop and are known to remain viable in the soil for a long time time (Mathur and Ram, 1963; Munjal, 1970). Thus, it is very important to assess the status of teliospores in soils of an area.

In order to assess the status of Karnal bunt inoculum in Jammu soils, four soil samples were randomly collected from all six districts falling with in Jammu division. Soil sampling (approximately 100 g) was done from four corners and one from centre of each selected field, which was followed by thorough mixing of all the five samples. 10 g of thoroughly mixed soil sample from selected hot spot was further taken up for quantification of teliospores. Four hot spots per district were randomly selected and further analyzed (Singh *et al.,* 1990).

Quantification of teliospores among soil samples of Jammu division :

Teliospores of are known to remain viable in the soil for a long time, thus acting as potent inocculum load for next crop (Mathur and Ram, 1963; Munjal, 1970). Teliospores get into the soil during harvest, threshing or winnowing or as seed contaminant. Status of soil inoculum load significantly determines disease incidence in an area, thus a study was carried out to generate soil mapping for the presence of Karnal bunt inoculum load in Jammu division. (Singh. *et al.* 1990). For extraction of teliospores from soil, thoroughly homogenized soil samples collected from hot spots in Jammu division were used. 10 g of homogenized soil was taken up from each soil sample and then subjected to oven drying at 105°C for 24 hrs before further processing. Oven dried soil was taken up in a 500 ml beaker in which 200 ml double distilled water and 1 ml mineral oil was added. Soil suspension thus prepared was subjected to agitation over magnetic stirrer for 5 minutes. The suspension after being thoroughly homogenized was allowed to settle for 2 hours. The supernatant thus formed was sieved through 20 mμ mesh, it was then back washed with distilled water and a final volume was made up to 200 ml. Teliospore count per ml was taken under light microscope using Hawksley eelworm cell (Datnoff *et al*., 1988).

RESULTS AND DISCUSSION

The disease was observed in all the districts surveyed in Jammu division of Jammu & Kashmir. During survey highest disease incidence was recorded in Rajouri (1.64%) and Udhampur (1.66%), followed by Kathua (1.58%), Doda (1.41), Jammu (1.28%) and least in Poonch (0.90%) (Table 1) .

Table 1 : Per cent disease incidence in different districts of Jammu division

Districts surveyed	Per cent infected grains		
	2006-07	2007-08	Pooled
Jammu	1.08 (1.44)	1.48 (1.57)	1.28 (1.50)
Kathua	1.55 (1.59)	1.61 (1.61)	1.58 (1.60)
Udhampur	1.79 (1.66)	1.53 (1.58)	1.66 (1.62)
Poonch	0.93 (1.34)	0.87 (1.32)	0.90 (1.33)
Doda	1.30 (1.51)	1.53 (1.58)	1.41 (1.54)
Rajouri	1.64 (1.61)	1.69 (1.63)	1.66 (1.62)
C.D.(P=0.05)	0.18	0.18	0.13

Soil samples were collected from four locations, per district surveyed. Data (Table 2) provide the evidence that Poonch had highest teliospore count in soils (7.5) followed by Rajouri (7.0). District Udhampur recorded teliospore count of 6.5 per 10 ml of soil analyzed. District Doda recorded 1.5

teliospores per 10 ml of soil and least teliospore count among all the six districts surveyed, Jammu soils recorded only 2.0 teliospores per 10 ml of soil analyzed.

Table 2 : District wise population of teliospores in soil

Sr. No.	Districts	Pooled spore count/10 mg soil
1.	Jammu	2.0 (1.6)
2.	Kathua	2.5 (1.7)
3.	Udhampur	6.5 (2.7)
4.	Poonch	7.5 (2.9)
5.	Doda	1.5 (1.50)
6.	Rajouri	7.0 (2.8)
C.D. (P=0.05)		1.70

*Figures in parentheses are square root transformed values

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RESEARCH ARTICLE

Preference of mustard aphid, *Lipaphiserysimi* (Kalt.) to different *Brassica* species

■ ARUN KUMAR SINGH* AND M.N. LAL

Department of Entomology, N.D. University of Agriculture and Technology, Kumarganj, FAIZABAD (U.P.) INDIA
Email : mnlal@rediffmail.com

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*Corresponding author:
singharunent@gmail.com

ABSTRACT

Preference to *Lipaphiserysimi* Kalt, on different *Brassica* species were carried out at Student's Instructional Farm of Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.) during *Rabi* 2009-2010 and 2010-2011 crop seasons. The seeds of six *Brassica* species, *viz.,* BSH-1 (*B. campestris* var. *brown sarson*), YST-151 (*B. campestris* var. *yellow sarson*), Varuna (*B. juncea*), HYOLA-401 (*B. napus*), Kiran (*B. carinata*) and T_{-27} (*Eruca sativa*) were sown to record the aphid population. *Lipaphiserysimi* Kalt. appeared on plants during the second week of January and continued upto harvesting in both the years . First observation was taken on second week in both the years . The minimum population of 1.63 /10 cm terminal shoot/plant and 1.47/10cm terminal shoot/plant were observed on species Kiran (*B. carinata*) during 2009-2010 and 2010-11, respectively and the maximum population of 2.62/10cm terminal shoot/plant and 2.82/10 cm terminal shoot/plant on species BSH-1 (*B. campestris* var. *brown sarson*) during 2009-2010 and 2010-2011. The peak population of *Lipaphiserysimi* Kalt., was observed on eighth standard week. Minimum pest population was 33.00cm terminal shoot/plant on species T_{-27} (*Eruca sativa*) and 29.72/ 10cm terminal shoot/plant on species Kiran (*B. carinata*) the maximum populations were219.07/ 10 cm terminal shoot/plant and 199.10/10cm terminal shoot/plant on species BSH-1 (*B. campestris* var. *brown sarson*) during 2009-2010 and 2010-2011, respectively .The result showed that among all the species under observation *Lipaphiserysimi* preferred the species- BSH-1 (*B. campestris* var. *brown sarson*) than the others species.

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INTRODUCTION

Rapeseed-mustard is most important source of edible oil for human consumption. India is the second largest producer of rapeseed-mustard after China. To increase the productivity of this commodity, various modern techniques of agricultural practices such as use of high yielding varieties and heavy manuring were used (Srivastava and Guleria, 2003).Rapeseed-mustard is highly vulnerable to attack of various insect pests. In this regard, Bhaketia and Sekhon (1989) reported more than three dozens insect-pests associated with this crop. Among them, mustard aphid, *Lipaphiserysimi* Kalt. has been thoroughly studied as serious insect- pest of this crop.Most of the farmers are not aware with the effect of chemical pesticides and still using most of the systemic and organic insecticides to control this insect pest. Injudicious and continuous use of insecticides may be deleterious to agro-ecosystem, public health and create residual problems. Therefore, the losses caused by insect pests particularly aphids have compelled the entomologists to develop control strategies for these insect pests. Feeling the gravity of the situation, the study was carried out to assess the species preference of *Lipaphiserysimi* Kalt to different *Brassica* species under agro-ecological conditions of Faizabad, district in Uttar Pradesh.

MATERIALS AND METHODS

Field experiments were conducted at Students Instructional Farm, N.D. University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) during the two consecutive years 2009-2010 and 2010-2011. *Brassica* species cv. BSH-1 (*B. campestris* var. *brown sarson*), YST-151 (*B. campestris* var. *yellow season*), Varuna (*B. juncea*), HYOLA-401 (*B. napus*), Kiran (*B. carinata*) and T_{-27} (*Eruca sativa*) were sown on November 20 in both the study years, and the effect was studied on the incidence of aphid on this crop. The experiments were laid out in Randomized Block Design (RBD) with four replications, each in 4 x 3m plot size. The spacing between row to row and plant to plant were 30 cm and 15 cm, respectively. All the recommended agronomic practices were followed to raise the crop except plant protection measures.

Regular observations on the population of mustard aphid were recorded throughout the growing season of the crop. The crop was monitored regularly for initial incidence as well as for population count of mustard aphid. For recording population count of mustard aphid, 10 plants were randomly selected from each plot and the population of mustard aphid was recorded at weekly interval by removing aphids from 10 cm top portion of the terminal short of each plant with the help of camel hair brush on a white paper. However, insecticides were not sprayed in and around the experimental area.

RESULTS AND DISCUSSION

The detailed results on various aspects of aphid, *Lipaphiserysimi* development are discussed as follows. The results of mean aphid population, 10cm terminal shoot/plan on different *Brassica* species at weekly intervalstarting from the appearance of aphid till maturity of the crop are presented in Table 1 and 2. A critical review of the data showed that

Table 1: Incidence of mustard aphid, *Lipaphiserysimi* on different *Brassica* spp. during *Rabi* 2009-2010

Standard weeks	Number of aphids/plant					
	BSH-1	Yst-151	Varuna	Hyola-401	Kiran	T_{-27}
2	2.62 (1.75)	2.22 (1.63)	2.05 (1.65)	1.90 (1.53)	1.63 (1.45)	2.50 (1.70)
3	5.50 (2.44)	4.15 (2.13)	3.30 (1.94)	3.12 (1.89)	3.25 (1.93)	3.08 (1.86)
4	16.35 (4.10)	15.75 (4.02)	10.68 (3.33)	4.75 (2.27)	3.70 (2.31)	5.28 (2.38)
5	31.05 (5.60)	25.48 (5.08)	27.90 (5.32)	15.40 (3.98)	9.85 (3.20)	11.90 (3.50)
6	55.83 (7.50)	51.50 (7.20)	47.83 (6.93)	19.45 (4.45)	13.20 (3.67)	15.80 (4.01)
7	154.60 (12.40)	137.10 (11.63)	129.90 (11.40)	28.45 (5.35)	20.40 (4.56)	27.80 (5.28)
8	219.07 (14.80)	194.27 (13.95)	175.52 (13.26)	61.65 (7.86)	33.00 (5.74)	40.42 (6.38)
9	47.98 (6.90)	34.18 (5.86)	25.80 (6.01)	14.58 (3.87)	11.70 (3.49)	21.40 (4.68)
10	11.95 (3.52)	12.20 (3.54)	12.33 (3.56)	7.50 (2.81)	4.85 (2.30)	14.20 (3.81)
11	4.85 (2.29)	3.47 (1.99)	6.17 (2.58)	5.50 (2.44)	2.58 (1.73)	5.58 (2.44)
12	0.15 (0.80)	0.17 (0.82)	1.60 (1.44)	1.90 (1.54)	0.73 (1.06)	3.55 (2.00)

Figures in parentheses are square root transformed values

Table 2: Incidence of mustard aphid, *Lipaphiserysimi* on different *Brassica* spp. during *Rabi* 2010-2011

Standard weeks	Number of aphids/plant					
	BSH-1	Yst-151	Varuna	Hyola-401	Kiran	T_{-27}
2	2.82 (1.80)	2.10 (1.60)	2.27 (1.65)	2.10 (1.60)	1.47 (1.40)	1.95 (1.54)
3	5.35 (2.41)	3.07 (1.88)	3.92 (2.06)	2.90 (1.83)	2.57 (1.73)	2.60 (1.75)
4	15.80 (4.01)	10.68 (3.33)	11.83 (3.50)	4.10 (2.13)	4.27 (2.18)	4.30 (2.17)
5	28.68 (5.38)	20.05 (4.52)	23.73 (4.90)	13.13 (2.68)	9.70 (3.18)	8.13 (2.92)
6	50.40 (7.12)	29.75 (5.49)	41.63 (6.47)	19.43 (4.45)	13.58 (3.73)	11.20 (3.40)
7	118.9 (10.89)	82.35 (9.09)	103.2 (10.18)	26.85 (5.20)	21.08 (4.63)	17.90 (4.28)
8	199.1 (14.12)	184.85 (13.66)	173.12 (13.17)	57.20 (7.55)	29.72 (5.47)	39.42 (6.21)
9	49.58 (7.06)	29.20 (5.42)	42.83 (6.54)	14.03 (3.80)	11.83 (3.48)	10.30 (3.28)
10	20.90 (4.59)	11.75 (3.49)	17.32 (4.20)	5.75 (2.48)	4.32 (2.17)	4.63 (2.26)
11	4.92 (2.31)	6.22 (2.58)	11.28 (5.21)	5.27 (2.39)	2.42 (1.70)	2.85 (1.84)
12	0.20 (0.83)	0.11 (0.77)	0.25 (0.86)	2.35 (1.68)	2.45 (1.71)	0.37 (0.90)

Figures in parentheses are square root transformed values

aphid population varied significantly with *Brassica* species.The population of aphids declined gradually towards the maturity of the plants in both the years. The infestation of *Lipaphiserysimi* on species YST-151 (*B. campestris* var. *yellow season*), appeared during second week of January (2.22/10 cm terminal shoot/plant and 2.10/10 cm terminal shoot/plant). *Lipaphiserysimi* multiplied very rapidly during January and February and reached to its peak (194.27/10 cm terminal shoot/plant and 184.85/10 cm terminal shoot/plant) duringfourth week of February. Thereafter pest population declined during the third week of March due to crop maturity during both year. The abundance of *Lipaphiserysimi* on species Varuna (*B. juncea*) was recorded during second week of January (2.05/10 cm terminal shoot/plant and 2.27/10 cm terminal shoot/plant) and aphid population multiplied rapidly and reached to its peak (175.52/10 cm terminal shoot/plant and 173.12/10 cm terminal shoot/plant) during fourth week of February and declined gradually with crop maturity in both the years .The infestation of *Lipaphiserysimi* on species BSH-1 (*B. campestris* var. *brown sarson*) was comparatively higher(2.62/10 cm terminal shoot/plant and 2.82/10 cm terminal shoot/plant)) during 2009-2010 and 2010-2011, respectively than rest of the varieties under observational trial. The population of *Lipaphiserysimi* multiplied rapidly in February and reached at peak (219.07/10 cm terminal shoot/plant and 199.10/10 cm terminal shoot/plant) during fourth week of February and aphid population declined rapidly towards the maturity of crop.The population of *Lipaphiserysimi* on species HYOLA-401 (*B. napus*), was (1.90/10 cm terminal shoot/plant and 2.10/10 cm terminal shoot/plant) on second week of January.The *Lipaphiserysimi* increased its population and reached at its peak (61.65/10 cm terminal shoot/plant and 57.20/10 cm terminal shoot/plant) on fourth week of February. The population of *Lipaphiserysimi* gradually declined during the first week of March during in both the crop seasons .The appearance of aphid population on species $T-_{27}$ (*Eruca sativa*) was recorded during second week of January (1.63/10 cm terminal shoot/plant and 1.95 /10 cm terminal shoot/plant). The aphid infestation increased gradually with plant reproductive stages and reached to peak (40.42/10 cm terminal shoot/plant and 39.42/10 cm terminal shoot/plant) during fourth week of February during 2009-2010 and 2010-2011. The infestation and abundance of *Lipaphiserysimi* on species Kiran (*B. carinata*), was lower (1.63/10 cm terminal shoot/plant and 1.47/10 cm terminal shoot/plant) during second week of January than other varieties. The pest population multiplied gradually and reached maximum (33.00/10 cm terminal shoot/plant and 29.72/10 cm terminal shoot/plant) during last week of February and declined rapidly during first week of March during 2009-2010 and 2010-2011, respectively. The results on preference of *Lipaphiserysimi* Kalt., on different *Brassica* species showed that the incidence of *Lipaphiserysimi* were recorded during second week of January .The population of *Lipaphiserysimi* rapidly multiplied and reduced gradually in first week of March due to maturity of the crop. The results showed that maximum aphid population was observed on species BSH-1 (*B. campestris* var. *brown sarson*) followed by YST-151 (*B. campestris* var. *yellow season*), Varuna (*B. juncea*), HYOLA-401 (*B. napus*), $T-_{27}$ (*Eruca sativa*) and Kiran (*B. carinata*) respectively. Naveen *et al*. (1996) studied the influence of crop morphophenological parameters on infestation of *Lipaphiserysimi* (Kalt) on *Brassica* genotypes and reported that *Lipaphiserysimi* appeared in the 4th week of January and continued upto the third week of March. Ram and Gupta (1987) reported that cloudy weather caused an increase in aphid population.

Conclusion :

On the basis of data presented, it could therefore be concluded that:

- The aphid, *Lipaphiserysimi* (Kalt.) preferred the *Brassica* species from second week of January to third week of March.
- The species BSH-1 (*B. campestris* var. *brown sarson*) and YST-151 (*B. campestris* var. *yellow season*) were comparatively susceptible to aphid and Kiran (*B. carinata*) and $T-_{27}$ (*Eruca sativa*)were resistants.

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RESEARCH ARTICLE

Survey of root diseases of chickpea in Jalana district of Marathwada region

■ O.D. KOHIRE, M. B. MULUK, V. O. KOHIRE PATIL, B. B. THOMBRE* AND S. S. MORE

Agriculture Research Station Badanapur, JALNA (M.S.) INDIA

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*Corresponding author:
bthombre@gmail.com

ABSTRACT

A field survey was conducted during 2008-2009, which revealed 5.53 to 11.69 per cent wilt disease in Jalana district of Marathwada region. Survey and surveillance of chickpea wilt in the Jalana district revealed average wilt complex to the tune of 8.43 per cent. Tahsil survey report indicated maximum wilt increase in tahsil Partur (11.69%) followed by Ghansawangi (10.31%), Jalana (10.22%) Bhokardan (9.91 %) Badanapur (7.10%), Ambad (6.77%), Mantha (6.15%) and Jafarabad (5.53%). Further study indicated that *Fusarium oxysporum* f.sp. *ciceri* was associated in majority of cases, pathogen was isolated, purified and its pathogenecity was proved in plastic cup pot. On the basis of morphological, cultural characteristics of pathogen and symptomatology, the fungal pathogen was identified as *a Fusarium oxysporium* f.sp. *ciceri*.

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INTRODUCTION

Chickpea (*Cicer arientinum* L.) is one of the important *Rabi* grain legume cultivated over an area of 4.01 lakh per hectare with the production of 3.11 lakhs tones in Marathwada (Annonymous, 2010). The chickpea wilt caused by *Fusarium oxysporium* f.sp. *ciceri* (Padwick) Snyd. and Hans. is wide spreading almost all the chickpea growing region in the state. The fungus is soil and seed borne and survives in soil in the absence of host or at least 6 year (Haware *et al.* 1986 a and b) causing losses up to 100 per cent. There is an increasing trend in occurrence of the disease in the state due to cultivation of chickpea under irrigated conditions. Considering the nature of damage and survival ability of the fungus, use of resistant varieties is the only economical and practical solution. Most of the resistant varieties have been found to be susceptible after some years because of breakdown in their resistance and evolution of variability in pathogen. Considering the variable types of the wilt reactions of released variety in the farmers field and sick plot at different locations and yield losses caused, the present investigation was undertaken to find out the major causal organisms involved in chickpea wilt complex in Marathwada region of Maharashtra state. Survey and surveillance of chickpea wilt complex incidence of farmer's field was made and collection. isolation, purification and pathogenecity of wilt pathogen were done accordingly.

MATERIALS AND METHODS

Survey and surveillance :

A roving survey of chickpea fields was conducted in tahsils *viz.,* Jalana, Mantha, Partur, Ambad, Ghansawangi, Badnapur, Bhokardan and Jafrabad of Jalana district during the month of December to record the occurrence and distribution of chickpea wilt. On an average, ten farmers' fields of chickpea in each tahsil were visited and the per cent wilt incidence was recorded. Chickpea plants showing typical wilt symptoms were collected in separate paper bag and brought to the laboratory for further investigations.

Isolation, pathogenicity, reisolation and symptomatology :

Chickpea plants, naturally infected and wilted with typical symptoms of wilt were collected from farmer's field and brought to the laboratory. All samples collected from different locations were subjected to the isolation on PDA in the laboratory.

Pathogenicity :

Pathogenicity of the organism was confirmed by sick soil inoculation in plastic cups under green house conditions by using susceptible cultivar, JG-62. The culture of *Fusarium oxysporum* f.sp.*ciceri* was multiplied on Sand maize flour medium. Fifteen gram of maize flour was mixed in 85 gram of river bed sand and filled in the conical flasks of 250 ml capacity (50g / flask) and steriled in autoclave at 1.04 kg cm^2 for 30 minutes. Then these flasks were inoculated aseptically with pure culture of *Fusarium oxysporum* f.sp.*ciceri* and incubated at room temperature for 15 days. After 15 days of incubation, the inoculum was taken out from the flask and mixed thoroughly with sterilized sand + soil mixture (1:1) @ 100 g inoculum per kg soil. This potting mixture (sand + soil+ inoculum) was filled in each plastic cup sterilized with 0.1 % $HgCl_2$ and incubated for four days. Then the seeds of highly susceptible variety, JG-62 were sown @ 10 seeds per plastic cup. The plastic cup with uninoculated soil served as control. All these plastic cup were then watered lightly and kept in glass house for further recording of observations on per cent seed germination, seedling mortality etc. The observations on wilt incidence were recorded after 15 days sowing up to wilting. Re-isolation of the fungus was made from roots artificially inoculated and diseased plants showing the typical symptoms of wilting.

The fungus growth obtained was transferred on PDA slants for comparison with original culture of *F. oxysporum* f.sp. *ciceri*. The symptoms of wilting were observed and recorded right from the initiation of disease till complete wilting of plants both in plastic cup culture as well as field condition. The culture of the pathogen obtained was identified on the basis of morphological and cultural characteristics.

Influence of different media :

Growth characters and sporulation ability of the isolated *Fusarium oxysporum* f.sp.*ciceri* were studied by growing it on different agar culture media. The media used were Czpek's dox agar medium, Asthana and Hawker's medium, Martin Rose Bengal agar, Potato dextrose agar, and Richard's agar. These agar media were prepared by following standard laboratory procedure given by Twite (1969), sterilized by autoclaving and poured in the sterilized Petri plates (ten plates of each medium) allowed to cool down and solidify. Then these plates were inoculated by placing a fungal disc (5 mm diameter) at the centre of the medium in plates and incubated at room temperature for a week.

RESULTS AND DISCUSSION

The results of the present study as well as relevant discussions habe been presented under following sub heads:

Survey and surveillance :

Data are presented in Tables 1 and 2. From the results presented in Table 1, it is revealed that heavy disease incidence was noticed in Partur tahsil (11.69 per cent) followed by Ghansawangi (10.31%) and moderate in Jalna (10.22%) and Bhokardan (9.91%) tahsils. Lowest disease incidence was in Mantha (6.15%) and Jafrabad (5.53%) and average disease incidence was recorded in Jalna district which was to the tune of 8.43 per cent. Similar findings were reported previously by Kohire *et al.* (2006).

Data of Table 2 on per cent wilt incidence in different chickpea cultivars grown on farmers field indicated, maximum incidence of wilt (average 12.82%) in local chickpea cultivar followed by BDN-9-3(7.95%) and Vishal (7.65%) and lowest incidence (3.78 %) was recorded in BDNG-797. Tahsil wise wilt incidence revealed that in all cultivars including local, maximum incidence was recorded in tahsil 16.25 per cent followed by Partur (15.25%) and Jalna (15.03%).

Results presented in Table 3 revealed that out of 80 samples isolated and studied, near about 67 (77.90%) proved the association of *Fusarium oxysporum* f.sp. *ciceri* followed by 15 (17.44%) of *Rhizoctonia bataticola* and 4 (4.65%) of *Sclerotium rolfsii* with chickpea wilt complex. Kohire *et al.* (2006) carried out survey and surveillance of chickpea wilt and reported that disease incidence of wilt varied from 6.6 to 18.5 per cent. These results clearly indicated that the major pathogen associated with chickpea wilt complex was *Fusarium oxysoprum* f.s. *ciceri* during early as well as later stages of the crop and to some extent, *Rhizoctonia bataticola* and *Sclerotium rolfsii* specially in early stage of the crop.

Isolation and pathogenicity :

The fungus, *Fusarium oxysporum* f.sp. *ciceri* was isolated from the wilted plants collected during the survey of Jalna district. The pure culture was obtained by hyphal tip method, subcultured frequently and maintained PDA slants for further studies.

Pathogenicity of the fungus was carried out in plastic cup by soil inoculation method using variety JG-62 which exhibited wilting after 30 days of inoculation. The findings of this test are presented in Table 4 and 5 . The inoculated seeds with pathogen, *Fusarium oxysporum* f. sp. *ciceri* exhibited 65 per cent overall germination where 40 per cent of the population mortality observed in pre-emergence condition and 21 per cent and 72 per cent post-emergence mortality had been occurred on 2nd and 3rd week after inoculation, respectively (Table 4). Similarly, the leaf yellowing of 60 per cent and 75 per cent was observed on 3rd and 5th day after inoculation, respectively with 100 per cent seedling mortality (Table 5).

Symptoms of wilting produced by artificially inoculated and diseased plants were identical and confirmed with those