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Chilli Fruit rot complex and die-back in South India

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Chilli (*Capsicum annuum* L.) is one of the important spice/vegetable/cash crop grown in India which belongs to family solanaceae. Chilli fruit rot disease is major yield limiting factor. It has been observed to occur in three phases *viz*.,damping off stage or seedling blight, prevalent in the nursery, die back stage which is initiated at different stages of growth and fruit rot stage in which the ripe fruits are infected. The last phase causes extensive damage to the fruits since the lesions on the fruits considerably reduce the market value and quality of the produce. An intensive roving survey was carried out during 2012-13 and 2013-14 (*kharif* and *rabi/* summer) in major chilli growing states of South India *viz*., Andhra Pradesh, Maharashtra, Karnataka to know the incidence and severity of fruit rot disease. The highest fruit rot incidence (19.97%) with 13.77 PDI was observed in Maharashtra followed by Andhra Pradesh (19.82%, 13.07 PDI). From infected fruits, pathogens like *Colletotrichum capsici, C. gloeosporioides, Alternaria alternata, Fusarium oxysporum* and *F. sporotrichioides* were isolated. Frequency of occurrence of single pathogen was always less compared to combination of pathogens. In combination of *C. capsici* and *Fusarium* spp. were found in 28.37 per cent where as *C. capsici* with *A. alternata* was 11.35 per cent. combination of *C. capsici, C. gloeosporioides* and *A.alternata* was 10.64 per cent.

Key words: Chilli, fruit rot, die-back, survey, incidence, *Colletotrichum, Alternaria, Fusarium*

INTRODUCTION

Chilli (*Capsicum annuum* L.) is one of the very popular spice/ vegetable crops grown worldwide known for its medicinal and health benefiting properties. This crop is suffering from several economically important diseases. Fruit rot disease caused by fungi *Colletotrichum* spp. (namely *C. capsici*, *C. gloeosporioides* and *C. acutatum*), *A. alternata*, and *Fusarium* spp. is major yield limiting factor in all chilli growing areas (Akhtar, 2007; Santoshreddy Machenahalli *et al.* 2012). The interaction study between chilli fruit rot showed that there is a increase in severity of fruit rot and it is a complex disease. The infected seeds act as a primary source of inoculum and plant debris, infected fruits as a secondary inoculum (Santoshreddy Machenahalli *et al.* 2014a). The prevalence and distribution of chilli fruit rot disease, severity of the disease, pathogen diversity and their frequency in various geographical regions of South India *viz*., Andhra Pradesh, Maharashtra, Karnataka is presented in this paper.

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MATERIALS AND METHODS

An intensive roving survey was carried out during 2012-13 and 2013-14 (*kharif* and *rabi/ summer*) in major chilli growing states of South India *viz*., Andhra Pradesh, Maharashtra, Karnataka to know the incidence and severity of fruit rot disease.

During 2012-13, totally 56 villages belonging to 15 taluks of 7 districts of Karnataka state, four taluks belonging to Kurnool district of Andhra Pradesh and three villages of Solapur district of Maharashtra state were surveyed. In each field, 10 plants were selected in zig zag manner starting from one end of field and noted the disease incidence and graded according to the scale and calculated disease severity. Similarly in 2013-14, totally 57 villages belonging to 15 taluks of seven districts of Karnataka, 20 villages belonging to six taluks of

two districts of Andhra Pradesh were surveyed.

Fruit rot severity was recorded by referring the following 0-9 scale given by Mayee and Datar (1986)

Grade	Per cent fruit area infection	Reaction
0	0	Immune
1	1-10	Resistant
3	11 – 25	Moderately resistant
5	26 – 50	Moderately susceptible
7	51 – 75	Susceptible
9	> 75	Highly susceptible

Per cent disease incidence of fruit rot was calculated by

$$\text{Per cent diseases incidence} = \frac{\text{Number of fruits infected}}{\text{Total number of fruits examined}} \times 100$$

Per cent Disease Index was calculated to estimate the disease severity of fruit rot disease :

$$\text{Fruit rot PDI} = \frac{\text{Sum of numerical disease rating}}{\text{Total no. of samples x Maximum of disease rating scale}} \times 100$$

The following die-back severity scale (0-9) was developed based on per cent branches infected (Fig.1) in each plant

Grade	Branches infected per plant (%)
0	0
1	1-10
3	11 – 25
5	26 – 50
7	51 - 75
9	> 75

Per cent disease incidence of die-back was calculated by

$$\text{Per cent disease incidence} = \frac{\text{Number of plants infected}}{\text{Total number of plants examined}} \times 100$$

Die-back severity was estimated as per the formula

$$\text{Die-back PDI} = \frac{\text{Sum of numerical disease rating}}{\text{Total no. of plants x Maximum of disease rating scale}} \times 100$$

Isolation and identification of pathogen/s

The pathogen/s were isolated from chilli plant samples collected during survey which showed the typical fruit rot and dieback symptom. The infected parts like fruit, twigs and fruit pedicel were cut into small bits and surface sterilized with one per cent sodium hypochlorite solution for two to three minutes and three times repeatedly washed in sterilized distilled water. Then the infected bits were transferred on to Petri dishes (1-2 bits per Petri dish) containing Potato Dextrose Agar (PDA) with the help of a sterile forceps and incubated at 25± 1°C for seven days. Further based on culture morphology and conidia pathogens were identified.

The frequencies of associated organisms in the infected chilli fruits

The frequencies of fungi and their dominance were also recorded by keeping the infected chilli fruits in a moist chamber for four days. Then the spores from the infected tissue were observed under microscope (400X). Based on morphology of spores fungi were identified. Frequencies of fungi were worked out for each sample which was collected from different geographical regions.

Pathogenicity test by pinprick method of inoculation

Ten days old cultures were used for artificial inoculation. Chilli fruits harvested at red ripened stage were surface sterilized with one per cent sodium hypochlorite solution and then washed in two changes of sterile water. Thereafter, the fruits were pricked with pin bundles specially designed for pricking. The pinpricked fruits were then dipped in spore suspension having 1 X 10^6 spores /ml for one minute. This procedure is followed for all *Colletotrichum* spp., *Fusarium* spp. and *A. alternata*. Further these fruits were kept for incubation on a perforated tray under humid chamber. The humid chamber was prepared by keeping water in the tray, which was placed below the perforated tray kept with inoculated fruits. Three wet cotton pieces were placed on the tray. The tray was covered with polythene sheet to maintain the relative humidity of over 90 per cent and then incubated at 25° ±1°C for eight days. After the development of symptom on the chilli fruits, reisolation of the fungus was made from the affected portion of the fruit as per the method described earlier and Koch's postulates were proved.

RESULTS AND DISCUSSION

Survey on the incidence and severity of disease helps to gather information on the prevalence, severity and distribution of disease. It reveals the magnitude of the problem on hand and serves as a precursor for evolving the management strategies. In the present investigation roving survey was undertaken during 2012 and 2013 in major chilli

growing states of South India *viz*., Andhra Pradesh (Guntur, Kurnool), Maharashtra (Solapur) and Karnataka (Bagalkot, Belgavi, Bellary, Dharwad, Gadag, Haveri, Koppal, Raichur) to assess the incidence and severity of fruit rot.

Survey during 2012-13 revealed that among three states the highest fruit rot incidence (19.97%) with 13.77 PDI was observed in Maharashtra followed by Karnataka (18.13%, 11.78 PDI), where as the highest die-back incidence (10.55%) with 43.90 PDI was observed in Andhra Pradesh followed by Karnataka (8.59%, 37.36 PDI) (Table 1a, 1b, 3). During 2013-14 the highest fruit rot incidence of 20.33 per cent with 13.31 PDI was observed in Andhra Pradesh followed by Karnataka (18.12%, 11.25 PDI), where as the highest die-back incidence of 11.44 per cent with 41.67 PDI was observed in Andhra Pradesh followed by Karnataka (9.54%, 38.92 PDI) (Table 2a,2b, 3).

From the pooled results of two years survey (2012-13 and 2013-14) it was observed that among the three states the highest fruit rot incidence (19.97%) with 13.77 PDI was observed in Maharashtra followed by Andhra Pradesh (19.82%, 13.07 PDI).

Among eight districts of Karnataka, the highest fruit rot incidence (22.18%) with 14.75 PDI was observed in Bellary, whereas the highest die-back incidence (11.18%) with 43.92 PDI was observed in Gadag. In Guntur district of Andhra Pradesh the highest fruit rot incidence (21.84%) with 12.98 PDI was recorded. Shivakumara (2006) reported that maximum fruit rot severity (11.56 PDI) was recorded in Gulbarga district followed by Raichur (11.17 PDI) district. Rajput (2011) reported that highest severity of fruit rot was noticed in Nalvadi and Sanshi villages of Dharwad district.

In the present study maximum fruit rot incidence and severity observed in Maharashtra and Andhra Pradesh is mainly due to irrigated condition with temperature of 25-30°C which is ideal for disease development. The same trend of temperature and irrigation is also followed in Bellary district. In these regions, chilli is grown in large area and also continuously year after year which leads to increase in inoculum of pathogens in seeds, plant debris and in soil. Use of untreated seeds which were produced locally is also one of the main reasons for increase in disease incidence and severity of fruit rot.

In the present survey it is observed that in both rainfed (17.66%, 11.34 PDI) and irrigated (18.96%, 12.23 PDI) conditions disease was equally distributed in severe form (Table 4a). Soil type (red and black) has no distinct differentiation for fruit rot disease. If the congenial weather condition and sufficient amount of inoculum is available then it leads to disease development in all these situations on commonly cultivated susceptible genotype like Byadgi Dabbi (Table 4b). It is observed that in both sole crop (18.58%, 11.95 PDI) and inter crop (17.52%, 11.36 PDI) disease was equally distributed in severe form, indicating that inter crop has never helped in reducing the disease (Table 4c).

The prevalence of fruit rot and die-back disease in different genotypes was also recorded during the survey (Table 5). The high fruit rot incidence (21.88 %) was recorded in LCA -960 with 11.33 PDI followed by Byadgi Dabbi (19.51 per cent, 11.80 PDI), where as less fruit rot incidence (10.72 %) was observed in C-341 with 9.10 PDI followed by Byadgi Kaddi genotype (15.87 %, 11.09 PDI). The high die-back incidence (10.84 %) was recorded in Theja with 42.91 PDI followed by Gadag local (10.05%, 42.87 PDI), where as less die-back incidence (7.81 %) was observed in Byadgi Kaddi with 29.20 PDI. It is indicating the susceptible nature of commonly cultivated genotypes *viz.,* Byadgi Dabbi, Byadgi Kaddi and Guntur (Shivakumara, 2006).

Symptoms observed during investigation

During survey different symptoms of the disease were noticed on seeds, seedlings, twigs, fruit and pedicel (Fig. 2).

Seeds

Discolored seeds with presence of mycelial bit were commonly observed in infected fruits. Such seeds were tested by standard blotter paper method which revealed growth of fungi on seeds. Further, it also showed seed and seedling rot. Acervulii of *Colletotrichum* were observed on plumule and radicle (Fig. 2a).

Seedling

When infected seeds were sown in sterile soil, they showed softening, rotting and decaying of tissues at collar region leading to damping off symptoms (Fig.2b, c).

Table 1a : Detailed survey on chilli fruit rot and dieback disease during 2012-13 in South India

State	District	Taluka	Village/ place	Area (ha)	Stage of crop	Geno type	Inter crop / sole crop	R/I	Soil type	Fruit rot		Die back		Pathogens noticed				
										Incidence (%)	PDI	Incidence (%)	PDI	Cc	Cg	Ca	F	A
Karnataka	Bagalkot	Bagalkot	Kagalgombe	2.0	Fruiting	Byadgi Dabbi	Sole crop	R	Black	19.18	13.42	11.48	46.38	-	+	-	-	-
			Lokapur	2.5	Fruiting	Byadgi kaddi	Sole crop	I	Black	22.75	15.64	9.27	34.28	+	-	-	+	-
			Kaladagi	2.0	Fruiting	Byadgi Dabbi	Sole crop	I	Red	18.48	11.73	10.27	37.82	+	-	-	+	-
			Mean							20.13	13.59	10.34	39.49					
	Range									19-23	11-16	9-12	34-47					
	Mean									20.13	13.59	10.34	39.49					
		Bellary	Koluru	4.0	Fruiting	Byadgi Kaddi	Sole crop	I	Red	26.52	18.60	8.42	39.84	+	-	-	-	+
			Raravi	6.0	Fruiting	Guntur	Sole crop	I	Black	18.36	13.40	6.74	34.46	+	-	+	+	-
			Sindigeri	4.0	Fruiting	Byadgi Dabbi	Sole crop	R	Red	23.72	16.21	7.89	36.92	+	+	-	-	+
										22.87	16.07	7.68	37.07					
	Bellary		Kerur	3.0	Fruiting	Byadgi Dabbi	Sole crop	R	Red	16.49	11.25	8.94	52.48	+	-	-	+	+
		Siraguppa	Siraguppa	4.0	Fruiting	Guntur	Sole crop	I	Red	18.62	14.79	10.46	41.92	-	+	-	+	-
			Shanvaspur	4.0	Fruiting	Byadgi Dabbi	Sole crop	I	Red	24.71	16.93	10.00	52.16	+	+	-	-	-
			Sirigeri cross	2.0	Fruiting	Byadgi Dabbi	Sole crop	I	Red	22.41	12.64	12.94	39.92	+	-	-	+	-
			Mean							20.55	13.90	10.58	44.67					
	Range									16-25	11-19	7-13	34-53					
	Mean									21.71	14.99	9.13	40.87					
	Dharwad	Dharwad	Amminabhavi	1.5	Fruiting	Byadgi Dabbi	Onion	R	Black	18.96	10.97	9.46	38.92	+	-	-	-	-
			Byahatti	2.0	Fruiting	Byadgi Dabbi	Onion	R	Black	15.48	9.34	8.72	34.83	-	+	-	-	+
			Govankoppa	1.5	Fruiting	Sitara	Sole	R	Black	12.73	9.21	9.14	35.82	+	-	+	-	-
			Kumbapur farm	2.0	Fruiting	Byadgi Dabbi	Sole crop	I	Red	19.54	12.46	8.76	33.94	+	-	-	+	+
			Somapur	1.0	Fruiting	Byadgi Dabbi	Onion	R	Black	21.73	13.81	10.16	31.24	+	-	-	-	+

Cc – *Colletotrichum capsici* Cg – *C. gloeosorioides,* Ca – *C. acutatum,* A – *Alternaria* sp., F – *Fusarium* spp.
R- Rainfed, I – Irrigated, + Present - Absent

Contd.

State	District	Taluka	Village/ place	Area (ha)	Stage of crop	Geno type	Inter crop / sole crop	R/I	Soil type	Fruit rot		Die back		Pathogens noticed				
										Incidence (%)	PDI	Incidence (%)	PDI	Cc	Cg	Ca	F	A
Karnataka	Dharwad	Hubli	Shivalli	1.5	Fruiting	Byadgi Dabbi	Onion	R	Black	24.14	12.07	9.43	40.78	+	-	-	+	-
			UAS Campus	2.0	Fruiting	Byadgi Dabbi	Sole crop	R	Black	22.73	11.73	8.93	41.05	+	+	+	+	+
									Mean	19.33	11.37	9.23	36.65					
			Hubli	2.0	Fruiting	Byadgi Dabbi	Sole crop	R	Black	14.25	10.71	12.83	48.29	+	-	-	-	+
			Hebsur	2.5	Fruiting	Byadgi Dabbi	Onion	R	Black	12.34	9.27	9.13	38.92	+	-	-	+	-
			Shirguppi	2.0	Fruiting	Byadgi Dabbi	Sole crop	R	Black	16.27	11.35	10.52	44.16	+	+	-	-	-
									Mean	14.29	10.44	10.83	43.79					
		Kundgol	Gudigeri	2.0	Fruiting	Byadgi Dabbi	Sole crop	R	Black	15.14	10.76	10.18	41.7	+	-	-	+	-
			Kundagol	5.0	Fruiting	Byadgi Dabbi	Sole crop	R	Black	17.19	11.41	9.27	40.31	+	-	-	-	+
			Sharewad	4.0	Fruiting	Byadgi Dabbi	Sole crop	R	Black	15.52	10.16	12.13	42.91	+	-	-	+	-
			Savnsi	2.0	Fruiting	Byadgi Kaddi	Sole crop	R	Black	12.31	8.94	9.43	36.81	+	-	-	-	-
									Mean	15.04	10.32	10.25	40.01					
		Navalgund	Alagavadi	3.0	Fruiting and flowering	Byadgi Dabbi	Onion	R	Black	14.13	11.74	9.14	35.27	+	-	-	+	-
			Byalal	2.5	Fruiting and flowering	Byadgi Dabbi	Onion	R	Black	16.10	12.15	8.92	34.93	+	-	-	+	-
			Gummagola	2.0	Fruiting and flowering	Byadgi Dabbi	Onion	R	Black	11.83	9.82	9.47	36.72	+	-	-	-	+
									Mean	14.02	11.24	9.18	35.64					
	Range									12-20	9-14	8-13	31-49					
	Mean									15.67	10.84	9.87	39.02					
	Gadag	Gadag	Binkadakatti	3.0	Fruiting and flowering	Gadag Local	Sole crop	R	Black	12.76	9.24	9.13	40.24	-	+	-	-	+
			Badrapur	2.0	Fruiting and	Byadgi	Cotton ,	R	Black	16.81	12.16	10.47	43.28	+	-	-	+	-
			Dumdur	1.5	Fruiting and flowering	Byadgi Dabbi	Cotton, onion	R	Black	20.47	14.38	9.81	40.31	+	-	-	+	-

Cc – *Colletotrichum capsici* Cg – *C. gloeosorioides,* Ca – *C. acutatum,* A – *Alternaria* sp., F – *Fusarium* spp.
R- Rainfed, I – Irrigated, + Present - Absent

Contd.

State	District	Taluka	Village/ place	Area (ha)	Stage of crop	Geno type	Inter crop / sole crop	R/I	Soil type	Fruit rot		Die back		Pathogens noticed				
										Incidence (%)	PDI	Incidence (%)	PDI	Cc	Cg	Ca	F	A
Karnataka			Hulkoti	2.0	Fruiting and flowering	Byadgi Dabbi	Cotton , onion	R	Black	18.32	10.13	13.18	48.91	+	-	-	-	+
									Mean	17.09	11.48	10.65	43.19					
	Range									12-21	9-15	9-14	40-49					
	Mean									17.09	11.48	10.65	43.19					
			Byadgi	2.0	Fruiting and flowering	Byadgi Dabbi	Sole crop	I	Black	20.19	12.20	7.43	32.31	+	+	-	-	+
	Haveri	Haveri	Devihosur	3.0	Fruiting and flowering	Byadgi Dabbi	Sole crop	R	Black	16.31	9.12	8.24	34.31	+	-	+	-	+
			Dummihal	1.5	Fruiting and flowering	Byadgi Kaddi	Sole crop	R	Black	14.28	8.41	9.21	39.21	+	-	-	+	-
									Mean	16.92	9.91	8.29	35.28					
			Guttal	2.0	Fruiting and flowering	Dyavanur Dabbi	Sole crop	R	Black	18.41	11.02	8.11	32.51	+	+	-	-	+
			Kadaramandalgi	2.5	Fruiting and flowering	Byadgi Dabbi	Sole crop	I	Black	26.18	14.17	9.02	34.10	+	-	-	-	-
		Ranebennur	Lingadahalli	2.0	Fruiting and flowering	Byadgi Dabbi	Sole crop	R	Black	18.21	10.43	0.00	0.00	+	-	+	-	-
			Ranebennur	1.0	Fruiting and flowering	Byadgi Dabbi	Sole crop	R	Black	23.40	12.10	8.14	34.32	+	-	-	+	-
									Mean	21.55	11.93	6.32	33.64					
	Range									18-27	10-15	0-9	0-35					
	Mean									19.23	10.92	7.30	34.46					
			Budugumpa	2.0	Fruiting and flowering	Local	Sole crop	I	Red	14.25	9.01	0.00	0.00	+	+	-	-	-
	Koppal	Gangavati	Kanakapur	1.5	Fruiting and flowering	Byadgi Kaddi	Sole crop	I	Red	9.71	4.83	0.00	0.00	-	+	-	+	-
									Mean	11.98	6.92	0	0					

Cc – *Colletotrichum capsici* Cg – *C. gloeosorioides,* Ca – *C. acutatum,* A – *Alternaria* sp., F – *Fusarium* spp.
R- Rainfed, I – Irrigated, + Present - Absent

Contd.

State	District	Taluka	Village/ place	Area (ha)	Stage of crop	Geno type	Inter crop / sole crop	R/I	Soil type	Fruit rot		Die back		Pathogens noticed				
										Incidence (%)	PDI	Incidence (%)	PDI	Cc	Cg	Ca	F	A
Karnataka	Raichur	Koppal	Basapur	2.0	Fruiting and flowering	Guntur	Sole crop	I	Red	13.16	8.42	0.00	0.00	+	-	-	-	-
			Beluru	1.5	Fruiting and flowering	Gadag local	Sole crop	I	Red	19.20	10.28	9.46	43.48	+	+	-	-	+
			Bommanal	2.0	Fruiting and flowering	Byadgi Kaddi	Sole crop	I	Red	12.30	9.20	5.20	27.4	+	-	-	+	-
			Dambarahalli	2.0	Fruiting and flowering	Guntur	Sole crop	I	Red	16.82	11.64	9.36	40.24	+	-	-	-	-
			Talakall	1.5	Fruiting and flowering	Byadgi Dabbi	Sole crop	R	Black	14.20	10.24	4.82	31.4	+	+	-	-	+
									Mean	15.14	9.96	5.77	28.50					
		Kustagi	Chikkatebinahal	2.0	Fruiting and flowering	Local	Sole crop	I	Red	12.30	7.92	8.94	38.00	+	-	-	+	-
			Kustagi	2.5	Fruiting and flowering	Byadgi Kaddi	Sole crop	I	Red	10.42	6.84	4.20	26.10	+	-	-	-	+
									Mean	11.36	7.38	6.57	32.05					
	Range									10-20	4-12	0-10	0-44					
	Mean									12.83	8.09	6.17	30.50					
		Manvi	Herekotneekal	4.0	Fruiting and flowering	Guntur	Sole crop	I	Black	27.52	19.60	9.42	39.84	+	-	-	+	+
			Kapgal	3.5	Fruiting and flowering	Byadgi kaddi	Sole crop	I	Black	16.04	10.32	9.66	38.33	+	+	-	-	+
			Neer manvi	3.0	Fruiting and flowering	Guntur	Sole crop	I	Red	21.55	11.93	6.32	17.73	+	-	-	-	+
									Mean	21.70	13.95	8.47	31.97					
		Raichur	Belgammanadoddi	4.0	Fruiting and flowering	Byadgi Dabbi	Sole crop	I	Black	22.87	11.07	10.68	47.07	+	-	+	-	+

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R- Rainfed, I – Irrigated, + Present - Absent

Contd.

State	District	Taluka	Village/ place	Area (ha)	Stage of crop	Geno type	Inter crop / sole crop	R/I	Soil type	Fruit rot		Die back		Pathogens noticed				
										Incidence (%)	PDI	Incidence (%)	PDI	Cc	Cg	Ca	F	A
			Mandapura	40	Fruiting and flowering	Byadgi Dabbi	Sole crop	I	Black	15.28	8.54	9.21	39.21	+	+	-	+	+
			Nelhal	5.0	Fruiting and flowering	Guntur	Sole crop	I	Black	23.40	12.10	8.14	34.32	+	-	-	+	+
			Panchamukhi	4.0	Fruiting and flowering	Byadgi Kaddi	Sole crop	R	Black	14.02	11.24	9.18	35.64	+	+	-	+	-
			Raichur	5.0	Fruiting and flowering	Byadgi Dabbi	Sole crop	I	Black	19.73	12.01	10.14	42.10	+	-	-	+	+
			Raladoddi	4.0	Fruiting and flowering	Guntur	Sole crop	I	Red	21.55	11.93	6.32	17.73	-	+	-	+	-
									Mean	18.79	11.16	8.59	36.01					
	Range									14-27	10-19	6-11	17-47					
	Mean									20.24	12.55	8.53	33.99					
			Alur	2.0	Fruiting and flowering	Byadgi Kaddi	Sole crop	I	Black	21.48	16.75	11.20	47.35	-	+	-	+	-
		Adoni	Madire	3.0	Fruiting and flowering	Brahma theja	Sole crop	I	Black	24.82	19.20	10.51	38.24	+	-	-	+	-
			Marakattu	2.0	Fruiting and flowering	Guntur	Sole crop	I	Black	20.31	14.26	-	-	+	-	+	-	+
									Mean	20.20	15.74	10.68	43.99					
Andhra Pradesh	Kurnool		Bodikanda	2.0	Fruiting and flowering	Theja	Sole crop	I	Black	12.50	9.71	8.17	38.16	+	-	-	+	-
			Emmiganur	2.5	Fruiting and flowering	Guntur	Sole crop	I	Red	16.89	12.40	12.00	44.28	+	+	-	-	+
		Emmiganur	Hanumapuram	3.0	Fruiting and flowering	C-341	Sole crop	I	Black	10.72	9.10	-	-	-	+	-	-	+
			Kotekallu	3.0	Fruiting and flowering	Guntur	Sole crop	I	Red	12.80	10.45	9.82	37.90	+	-	-	+	-
									Mean	13.23	10.42	10.00	40.11					

Cc – *Colletotrichum capsici* Cg – *C. gloeosorioides,* Ca – *C. acutatum,* A – *Alternaria* sp., F – *Fusarium* spp.
R- Rainfed, I – Irrigated, + Present - Absent

Contd.

State	District	Taluka	Village/ place	Area (ha)	Stage of crop	Geno type	Inter crop / sole crop	R/I	Soil type	Fruit rot		Die back		Pathogens noticed				
										Incidence (%)	PDI	Incidence (%)	PDI	Cc	Cg	Ca	F	A
			Dharmapuram	2.5	Fruiting and flowering	Guntur	Sole crop	I	Red	21.41	13.20	13.21	49.41	+	-	-	+	-
			Halaharavi	2.0	Fruiting and flowering	Theja	Sole crop	R	Black	18.31	11.45	9.67	42.46	+	-	-	-	-
		Mantralaya	Kalludevarakunta	2.0	Fruiting and flowering	Guntur	Sole crop	I	Red	20.26	12.00	10.72	43.41	-	+	-	-	+
			Manthralaya	2.0	Fruiting and flowering	Guntur	Sole crop	I	Red	18.40	10.73	-	-	+	-	+	+	-
									Mean	19.60	11.85	11.20	45.09					
		Nandavaram	Mugathi	2.0	Fruiting and flowering	Guntur	Sole crop	I	Red	14.20	12.73	10.32	46.40	+	-	-	-	-
Range										9-25	9-20	8-13	37-50					
Mean										16.81	12.69	10.55	43.90					
			Mangalaveda	2.0	Fruiting and flowering	Local	Sole Crop	I	Black	26.82	20.45	8.60	36.25	+	+	-	+	-
Maharashtra	Solapur	Pandarapur	Pandarapur	2.5	Fruiting and flowering	Capsicum	Sole Crop	I	Red	14.20	9.48	-	-	+	-	-	-	-
			Sangola	2.0	Fruiting and flowering	Local	Sole Crop	I	Red	18.91	11.40	6.80	33.90	+	-	-	+	+
									Mean	19.97	13.77	7.70	35.07					
Range										14-27	9-21	6-9	33-37					
Mean										19.97	13.77	7.70	35.07					

Cc – *Colletotrichum capsici* Cg – *C. gloeosorioides*, Ca – *C. acutatum*, A – *Alternaria* sp., F – *Fusarium* spp.
R- Rainfed, I – Irrigated, + Present - Absent

Table 1b : Mean percent disease incidence and severity of fruit rot and die-back disease of chilli during 2012-13 in different taluks of Karnataka, Andhra Pradesh and Maharashtra

State	District	Taluka	Fruit rot		Die back	
			Incidence (%)	PDI	Incidence (%)	PDI
Karnataka	Bagalkot	Bagalkot	20.13	13.59	10.34	39.49
		Mean	20.13	13.59	10.34	39.49
	Bellary	Bellary	22.87	16.07	7.68	37.07
		Siraguppa	20.55	13.90	10.58	44.67
		Mean	21.71	14.99	9.13	40.87
	Dharwad	Dharwad	19.33	11.37	9.23	36.65
		Hubli	14.29	10.44	10.83	43.79
		Kundgol	15.04	10.32	10.25	40.01
		Navalgund	14.02	11.24	9.18	35.64
		Mean	15.67	10.84	9.87	39.02
	Gadag	Gadag	17.09	11.48	10.65	43.19
		Mean	17.09	11.48	10.65	43.19
	Haveri	Haveri	16.92	9.91	8.29	35.28
		Ranebennur	21.55	11.93	6.32	33.64
		Mean	19.23	10.92	7.30	34.46
	Koppal	Gangavati	11.98	6.92	0	0
		Koppal	15.14	9.96	5.77	28.50
		Kustagi	11.36	7.38	6.57	32.05
		Mean	12.83	8.09	6.17	30.50
	Raichur	Manvi	21.70	13.95	8.47	31.97
		Raichur	18.79	11.16	8.59	36.01
		Mean	20.24	12.55	8.53	33.99
Andhra Pradesh	Kurnool	Adoni	20.20	15.74	10.68	43.99
		Emmiganur	13.23	10.42	10.00	40.11
		Mantralaya	19.60	11.85	11.20	45.09
		Nandavaram	14.20	12.73	10.32	46.40
		Mean	16.81	12.69	10.55	43.90
Maharashtra	Solapur	Pandarapur	19.97	13.77	7.70	35.07
		Mean	19.97	13.77	7.70	35.07

Twigs

Necrosis of tender twigs from the tip to backwards with brown to grayish white straw colored lesions developed. Further entire branch withered with defoliation. Black dots of fruiting bodies (acervulii) of pathogen were observed (Fig. 2d).

Fruit

Circular to elliptical sunken spots with salmon color and acervuli with conidia observed on *Colletotrichum* infected both red and green colored fruits (Fig. 3a, b, c, d, e). Black color spore masses with sunken lesions on *Alternaria* infected fruit (Fig. 4 a and b). Drying of fruit from tip with white mycelial growth accompanied pink color spore mass observed on *Fusarium* infected fruits (Fig. 4 c, d, e, f, g).

Pedicel

Brown color discoloration with black acervuli observed (Fig. 2 e, f).

Table 2a : Detailed survey on chilli fruit rot and dieback disease during 2013-14 in South India

State	District	Taluka	Village/place	Area (ha)	Stage of crop	Geno type	Inter Crop / Sole Crop	R/I	Soil type	Fruit rot		Die back		Pathogens noticed				
										Incidence (%)	PDI	Incidence (%)	PDI	Cc	Cg	Ca	F	A
Karnataka	Bellary	Bellary	Koluru	4.0	Flowering and Fruiting	Byadgi Kaddi	Sole Crop	I	Red	22.14	14.94	6.73	35.24	+	-	-	-	+
			Raravi	6.0	Flowering and Fruiting	Guntur	Sole Crop	I	Black	20.00	12.21	8.42	39.82	+	-	+	+	-
			Sindigeri	4.0	Flowering and Fruiting	Byadgi Dabbi	Sole Crop	R	Red	21.47	14.32	8.21	40.96	+	+	-	-	+
									Mean	21.20	13.82	7.79	38.67					
	Bellary	Siraguppa	Kerur	3.0	Flowering and Fruiting	Byadgi Dabbi	Sole Crop	R	Red	21.37	13.76	8.94	47.41	+	-	-	+	+
			Siraguppa	4.0	Fruiting	Guntur	Sole Crop	I	Red	24.00	14.91	10.46	38.32	-	+	-	+	-
			Shanvaspur	4.0	Flowering and Fruiting	Byadgi Dabbi	Sole Crop	I	Red	24.32	15.40	10.00	50.64	+	+	-	-	-
			Sirigeri cross	2.0	Flowering and Fruiting	Byadgi Dabbi	Sole Crop	I	Red	26.73	16.79	12.94	44.32	+	-	-	+	-
									Mean	24.10	15.21	10.58	45.17					
	Range									20-27	12-17	6-11	35-48					
	Mean									22.65	14.51	9.18	41.92					
	Belgavi	Soundatti	Inamhongal	2.0	Fruiting and flowering	Byadgi Dabbi	Onion	R	Black	18.19	11.20	10.19	42.70	-	+	-	-	-
			Panchagav	2.0	Fruiting and flowering	Byadgi Dabbi	Onion, coriander	R	Black	15.30	10.00	9.20	41.31	+	-	-	+	-
			Salahalli	1.5	Fruiting and flowering	Byadgi Dabbi	Onion	R	Black	10.20	8.40	12.12	40.91	+	-	-	+	-
			Soundatti	2.0	Fruiting and flowering	Byadgi Dabbi	Onion	R	Black	14.62	9.25	9.40	35.81	+	-	-	-	+
									Mean	14.58	9.71	10.23	40.18					
	Range									10-19	8-11	9-12	35-42					
	Mean									14.58	9.71	10.23	40.18					
	Dharwad	Dharwad	Amminabhavi	1.5	Fruiting	Byadgi Dabbi	Onion	R	Black	20.18	11.86	10.32	40.28	+	-	-	-	-
			Byahatti	2.0	Fruiting	Byadgi Dabbi	Onion	R	Black	16.39	9.86	10.86	40.12	-	+	-	-	+
			Govankoppa	1.5	Fruiting	Byadgi Kaddi	Sole Crop	R	Black	14.12	9.64	9.26	38.19	+	-	+	-	-
			Kumbapur farm	2.0	Fruiting	Byadgi Dabbi	Sole Crop	I	Red	16.24	11.83	9.14	36.85	+	-	-	+	+
			Somapur	1.0	Fruiting	Byadgi Dabbi	Onion	R	Black	20.74	10.91	9.20	38.94	+	-	-	-	+
			Shivalli	1.5	Fruiting	Byadgi Dabbi	Onion	R	Black	22.92	11.43	8.49	34.17	+	-	-	+	-
			UAS Campus	2.0	Fruiting	Byadgi Dabbi	Sole Crop	R	Black	26.84	14.35	9.12	63.84	+	+	+	+	+
									Mean	19.63	11.41	9.48	38.34					

Cc – *Colletotrichum capsici* Cg – *C. gloeosorioides,* Ca – *C. acutatum,* A – *Alternaria* sp., F – *Fusarium* spp.
R- Rainfed, I – Irrigated, + Present - Absent

Contd.

State	District	Taluka	Village/ place	Area (ha)	Stage of crop	Genotype	Inter crop / Sole crop	R/I	Soil type	Fruit rot		Die back		Pathogens noticed				
										Incidence (%)	PDI	Incidence (%)	PDI	Cc	Cg	Ca	F	A
Karnataka			Hubli	2.0	Fruiting	Byadgi Dabbi	Sole Crop	R	Black	18.27	12.14	12.83	48.29	+	-	-	-	+
		Hubli	Hebsur	2.5	Fruiting	Byadgi Dabbi	Onion	R	Black	13.84	10.13	9.13	38.92	+	-	-	+	-
			Shirguppi	2.0	Fruiting	Byadgi Dabbi	Sole Crop	R	Black	18.27	12.10	10.52	44.16	+	+	-	-	-
									Mean	16.79	11.46	10.83	43.79					
			Gudigeri	2.0	Fruiting	Byadgi Dabbi	Sole Crop	R	Black	16.42	11.12	10.18	41.70	+	-	-	+	-
		Kundgol	Kundagol	5.0	Fruiting	Byadgi Dabbi	Sole Crop	R	Black	20.83	12.76	9.27	40.31	+	-	-	-	+
			Sharewad	4.0	Fruiting	Byadgi Dabbi	Sole Crop	R	Black	17.32	11.20	12.13	42.91	+	-	-	+	-
			Savnsi	2.0	Fruiting	Byadgi Kaddi	Sole Crop	R	Black	14.91	10.28	9.43	36.81	+	-	-	-	-
			Mean							17.37	11.34	10.25	40.43					
			Alagavadi	3.0	Fruiting and flowering	Byadgi Dabbi	Onion	R	Black	16.27	12.37	11.25	39.19	+	-	-	+	-
		Navalgund	Byalal	2.5	Fruiting and flowering	Byadgi Dabbi	Onion	R	Black	13.27	10.21	9.64	37.12	+	-	-	+	-
			Gummagol a	2.0	Fruiting and flowering	Byadgi Dabbi	Onion	R	Black	14.28	11.14	10.82	41.36	+	-	-	-	+
									Mean	14.61	11.24	10.57	39.22					
	Range									13-21	9-15	8-13	36-64					
	Mean									17.10	11.36	10.28	40.45					
			Binkadakatti	3.0	Fruiting and flowering	Gadag Local	Sole Crop	R	Black	18.91	11.86	11.43	42.16	-	+	-	-	+
			Badrapur	2.0	Fruiting and flowering	Byadgi Dabbi	Cotton , Onion	R	Black	22.17	14.28	12.73	46.21	+	-	-	+	-
	Gadag	Gadag	Dumdur	1.5	Fruiting and flowering	Byadgi Dabbi	Cotton, Onion	R	Black	27.13	16.21	10.45	43.27	+	-	-	+	-
			Hulkoti	2.0	Fruiting and flowering	Byadgi Dabbi	Cotton , Onion	R	Black	20.74	12.14	12.18	46.92	+	-	-	-	+
			Mean						Mean	22.24	13.62	11.70	44.64					
	Range									18-28	11-15	10-13	42-47					
	Mean									22.24	13.62	11.70	44.64					
			Byadgi	2.0	Fruiting and flowering	Byadgi Dabbi	Sole Crop	I	Black	22.18	13.41	9.40	42.24	+	+	-	-	+
	Haveri	Haveri	Devihosur	3.0	Fruiting and flowering	Byadgi Dabbi	Sole Crop	R	Black	18.24	10.84	10.04	44.60	+	-	+	-	+
			Dummihal	1.5	Fruiting and flowering	Byadgi Kaddi	Sole Crop	R	Black	19.24	12.01	9.82	42.91	+	-	-	+	-
			Mean						Mean	19.88	12.08	9.75	43.25					
		Ranebennur	Guttal	2.0	Fruiting and flowering	Dyavanur Dabbi	Sole Crop	R	Black	20.61	10.14	9.42	41.50	+	+	-	-	+
			Kadaraman-dalgi	2.5	Fruiting and flowering	Byadgi Dabbi	Sole Crop	I	Black	22.40	11.84	10.13	46.31	+	-	-	-	-

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Contd.

State	District	Taluka	Village/ place	Area (ha)	Stage of crop	Genotype	Inter Crop / Sole Crop	R/I	Soil type	Fruit rot		Die back		Pathogens noticed				
										Incidence (%)	PDI	Incidence (%)	PDI	Cc	Cg	Ca	F	A
Karnataka			Lingadahalli	2.0	Fruiting and flowering	Byadgi Dabbi	Sole Crop	R	Black	21.08	10.97	8.21	31.42	+	-	+	-	-
			Ranebennur	1.0	Fruiting and flowering	Byadgi Dabbi	Sole Crop	R	Black	19.80	11.94	9.31	44.29	+	-	-	+	-
									Mean	20.97	11.22	9.27	40.88					
	Range									18-23	10-14	9-11	42-47					
	Mean									20.43	11.65	9.51	42.06					
		Gangavati	Budugumpa	2.0	Fruiting and flowering	Local	Sole Crop	I	Red	12.24	8.28	2.00	12.30	+	+	-	-	-
			Kanakapur	1.5	Fruiting and flowering	Byadgi Kaddi	Sole Crop	I	Red	11.42	6.41	1.00	10.24	-	+	-	+	-
			Mean						Mean	11.83	7.34	1.5	11.27					
		Koppal	Basapur	2.0	Fruiting and flowering	Guntur	Sole Crop	I	Red	12.01	8.13	0.00	0.00	+	-	-	-	-
			Beluru	1.5	Fruiting and flowering	Gadag local	Sole Crop	I	Red	21.40	12.18	10.18	45.60	+	+	-	-	+
			Bommanal	2.0	Fruiting and flowering	Byadgi Kaddi	Sole Crop	I	Red	14.80	11.42	7.21	31.20	+	-	-	+	-
			Dambarahalli	2.0	Fruiting and flowering	Guntur	Sole Crop	I	Red	18.42	12.82	9.36	40.24	+	-	-	-	-
			Talakall	1.5	Fruiting and flowering	Byadgi Dabbi	Sole Crop	R	Black	15.86	10.90	4.82	11.40	+	+	-	-	+
			Mean						Mean	16.50	11.09	6.31	25.68					
		Kustagi	Chikkatebinahal	2.0	Fruiting and flowering	Local	Sole Crop	I	Red	14.60	9.84	10.20	43.82	+	-	-	+	-
			Kustagi	2.5	Fruiting and flowering	Byadgi Kaddi	Sole Crop	I	Red	12.84	8.08	5.80	28.62	+	-	-	-	+
			Mean						Mean	13.72	8.96	8.00	36.22					
	Range									11-22	8-13	0-11	0-46					
	Mean									14.02	9.13	5.27	24.39					
		Manvi	Herekotteka l	4.0	Fruiting and flowering	Guntur	Sole Crop	I	Black	15.94	9.42	7.73	36.24					
			Kapgal	3.5	Fruiting and flowering	Byadgi kaddi	Sole Crop	I	Black	11.34	9.66	10.25	40.43	+	-	-	+	+
	Raichur		Neer manvi	3.0	Fruiting and flowering	Guntur	Sole Crop	I	Red	11.22	6.32	9.27	40.88	+	+	-	-	+
			Mean						Mean	12.83	8.47	9.08	39.18					
		Raichur	Belgammanadoddi	4.0	Fruiting and flowering	Byadgi Dabbi	Sole Crop	I	Black	22.87	11.07	9.79	42.67	+	-	-	-	+
			Mandapura	4.0	Fruiting and flowering	Byadgi Dabbi	Sole Crop	I	Black	15.28	8.54	10.82	44.91	+	-	+	-	+

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Contd.

State	District	Taluka	Village/place	Area (ha)	Stage of crop	Geno type	Inter Crop / Sole Crop	R/I	Soil type	Fruit rot		Die back		Pathogens noticed				
										Incidence (%)	PDI	Incidence (%)	PDI	Cc	Cg	Ca	F	A
Karnataka			Nelhal	5	Fruiting and flowering	Guntur	Sole Crop	I	Black	23.40	12.10	9.31	40.29	+	+	-	+	+
			Panchamukhi	4	Fruiting and flowering	Byadgi Kaddi	Sole Crop	R	Black	14.02	11.24	10.57	39.22	+	-	-	+	+
			Raichur	5	Fruiting and flowering	Byadgi Dabbi	Sole Crop	I	Black	19.73	12.01	9.84	39.41	+	+	-	+	-
			Raladoddi	4	Fruiting and flowering	Guntur	Sole Crop	I	Red	21.55	11.93	9.27	40.88	+	-	-	+	+
			Mean						Mean	18.79	11.16	9.96	40.94					
	Range									11-24	6-13	7-11	36-45					
	Mean									15.81	9.82	9.52	40.06					
			Kattavaripalem	5.0	Fruiting and flowering	LCA-960	Sole Crop	I	Black	19.47	10.26	9.10	38.92	-	+	-	+	-
			Medikonduru	4.0	Fruiting and flowering	LCA-960	Sole Crop	I	Black	24.29	12.40	10.25	41.34	+	-	-	-	-
		Sattanpalli	Paaldagu	3.0	Fruiting and flowering	Theja	Sole Crop	I	Black	18.48	11.74	10.00	40.00	+	+	-	-	+
			Pedakurpadu	2.5	Fruiting and flowering	G-888	Sole Crop	I	Black	20.50	12.45	8.26	36.20	+	-	-	+	+
	Guntur		Perecherla	4.0	Fruiting and flowering	Eldom-5	Sole Crop	I	Black	27.00	15.13	13.50	34.25	+	-	+	-	-
			Mean						Mean	21.94	12.39	10.22	40.14					
Andhra Pradesh			Ananthapuram	4.0	Fruiting and flowering	Theja	Sole Crop	I	Black	19.60	12.36	12.80	39.50	-	+	-	+	+
		Krosuru	Bayyavaram	5.0	Fruiting and flowering	G-888	Sole Crop	I	Black	20.00	12.00	10.80	38.48	-	+	-	-	+
			Peasapada	4.0	Fruiting and flowering	Theja	Sole Crop	I	Black	25.61	16.34	14.80	40.45	+	-	-	-	-
			Mean						Mean	21.73	13.56	12.8	39.47					
		Range								18-27	10-17	8-15	34-42					
		Mean								21.84	12.98	11.51	39.80					
			Bodikanda	2.0	Fruiting and flowering	Theja	Sole Crop	I	Black	14.71	11.20	10.82	41.43	+	-	-	+	-
			Emmiganur	2.5	Fruiting and flowering	Guntur	Sole Crop	I	Red	18.62	14.17	10.41	46.81	+	-	-	+	-
	Kurnool	Emmiganur	Hanumapuram	3.0	Fruiting and flowering	Guntur	Sole Crop	I	Black	13.60	10.32	-	-	+	+	-	-	+
			Kotekallu	3.0	Fruiting and flowering	Guntur	Sole Crop	I	Red	15.67	12.48	10.43	44.81	-	+	-	-	+
									Mean	15.65	12.04	10.55	44.35					

Cc – *Colletotrichum capsici* Cg – *C. gloeosorioides*, Ca – *C. acutatum*, A – *Alternaria* sp., F – *Fusarium* spp.
R- Rainfed, I – Irrigated, + Present - Absent

Contd.

State	District	Taluka	Village / place	Area (ha)	Stage of crop	Geno type	Inter Crop / Sole Crop	R/I	Soil type	Fruit rot		Die back		Pathogens noticed				
										Incidence (%)	PDI	Incidence (%)	PDI	Cc	Cg	Ca	F	A
Andhra Pradesh			Dharmapuram	2.5	Fruiting and flowering	Guntur	Sole Crop	I	Red	22.76	14.92	11.50	47.14	+	-	-	+	-
			Halaharavi	2.0	Fruiting and flowering	Theja	Sole Crop	R	Black	20.70	12.81	10.72	45.63	+	-	-	+	-
		Mantralaya	Kalludevarakunta	2.0	Fruiting and flowering	Guntur	Sole Crop	I	Red	22.49	13.27	14.81	40.12	+	-	-	-	-
			Mantralaya	2.0	Fruiting and flowering	Guntur	Sole Crop	I	Red	21.81	12.25	4.86	10.52	-	+	-	-	+
			Mean						Mean	21.94	13.31	10.47	35.85					
		Nandavaram	Mugathi	2.0	Fruiting and flowering	Guntur	Sole Crop	I	Red	16.40	13.10	12.19	48.90	+	-	+	+	-
			Alur	2.0	Fruiting and flowering	Byadgi Kaddi	Sole Crop	I	Black	22.92	17.40	10.41	46.18	+	-	-	-	-
		Adoni	Madire	3.0	Fruiting and flowering	Brahma theja	Sole Crop	I	Black	23.18	17.82	14.26	40.10	-	+	-	+	-
			Marakattu	2.0	Fruiting and flowering	Guntur	Sole Crop	I	Black	22.70	16.31	*	*	+	-	-	+	-
			Mean						Mean	21.30	16.16	12.29	45.06					
		Range								13-24	10-18	10-15	10-49					
		Mean								18.82	13.65	11.38	43.54					

Cc – *Colletotrichum capsici* Cg – *C. gloeosorioides*, Ca – *C. acutatum*, A – *Alternaria* sp., F – *Fusarium* spp.
R- Rainfed, I – Irrigated, + Present - Absent

Table 2b : Mean percent disease incidence and severity of fruit rot and die-back disease of chilli during 2013-14 in different taluks of Karnataka, Andhra Pradesh

State	District	Taluka	Fruit rot		Die back	
			Incidence (%)	PDI	Incidence (%)	PDI
Karnataka	Bellary	Bellary	21.20	13.82	7.79	38.67
		Siraguppa	24.10	15.21	10.58	45.17
		Mean	22.65	14.51	9.18	41.92
	Belgavi	Soundatti	14.58	9.71	10.23	40.18
			14.58	9.71	10.23	40.18
	Dharwad	Dharwad	19.63	11.41	9.48	38.34
		Hubli	16.79	11.46	10.83	43.79
		Kundgol	17.37	11.34	10.25	40.43
		Navalgund	14.61	11.24	10.57	39.22
		Mean	17.10	11.36	10.28	40.45
	Gadag	Gadag	22.24	13.62	11.70	44.64
		Mean	22.24	13.62	11.70	44.64
	Haveri	Haveri	19.88	12.08	9.75	43.25
		Ranebennur	20.97	11.22	9.27	40.88
		Mean	20.43	11.65	9.51	42.06
	Koppal	Gangavati	11.83	7.34	1.5	11.27
		Koppal	16.50	11.09	6.31	25.68
		Kustagi	13.72	8.96	8.00	36.22
		Mean	14.02	9.13	5.27	24.39
	Raichur	Manvi	12.83	8.47	9.08	39.18
		Raichur	18.79	11.16	9.96	40.94
		Mean	15.81	9.82	9.52	40.06
Andhra Pradesh	Guntur	Sattanpalli	21.94	12.39	10.22	40.14
		Krosuru	21.73	13.56	12.80	39.47
		Mean	21.84	12.98	11.51	39.80
	Kurnool	Adoni	21.30	16.16	12.29	45.06
		Emmiganur	15.65	12.04	10.55	44.35
		Mantralaya	21.94	13.31	10.47	35.85
		Nandavaram	16.40	13.10	12.19	48.90
		Mean	18.82	13.65	11.38	43.54

Predominance and frequency of pathogen/s causing fruit rot disease

Predominance of various pathogens was observed during survey. Occurrence of single pathogen was always less compared to combination of pathogens. The combination of *C. capsici* and *Fusarium* spp. was 28.37 per cent, *C. capsici* with *A. alternata* 11.35 per cent, combination of *C. capsici, C. gloeosporioides* and *A. alternata* was 10.64 per cent (Table. 6). Ramachandran *et al.* (2007) conducted survey and collected 92 isolates from different chilli growing areas in Andhra Pradesh and Karnataka. Among them 53 were identified as *C.capsici*, 38 as *C. gloeosporioides* and one was *C. acutatum*. Chilli fruit samples collected from Tamil Nadu, revealed that *C. capsici* was the most commonly isolated (69%) followed by *C. gloeosporioides* (19%) and *A. alternata* (Madhavan *et al.* 2010). Association of *Fusarium* spp. in the present study is supported by the work of Parey *et al.* (2013) who reported different *Fusarium* spp. were involved in fruit rot in Jammu and Kashmir.

Mild to severe form of fruit rot and die-back disease was observed irrespective of varieties during the field survey under taken. During 2012-13 and 2013 -14 such variation in disease incidence in different locations is quite often attributed to environmental conditions. However, the variations may also be attributed to the presence of variabil-

Table 3 : District wise mean percent disease incidence and severity of fruit rot and die-back disease of chilli during 2012-13 and 2013-14 of Karnataka, Andhra Pradesh and Maharashtra

State	District	Fruit rot						Die-back					
		Incidence (%)			PDI			Incidence (%)			PDI		
		2012-13	2013-14	Mean	2012-13	2013-14	Mean	2012-13	2013-14	Mean	2012-13	2013-14	Mean
Karnataka	Bagalkot	20.13	-	20.13	13.59	-	13.59	10.34	-	10.34	39.49	-	39.49
	Belgavi	-	14.58	14.58	-	9.71	9.71	-	9.18	9.18	-	40.18	40.18
	Bellary	21.71	22.65	22.18	14.99	14.51	14.75	9.13	10.23	9.68	40.87	41.92	41.40
	Dharwad	15.67	17.10	16.39	10.84	10.28	10.56	9.87	11.36	10.62	39.02	40.45	39.74
	Gadag	17.09	22.24	19.67	11.48	13.62	12.55	10.65	11.70	11.18	43.19	44.64	43.92
	Haveri	19.23	20.43	19.83	10.92	11.65	11.29	7.30	9.51	8.41	34.46	42.06	38.26
	Koppal	12.83	14.02	13.43	8.09	9.13	8.61	4.29	5.27	4.78	30.50	24.39	27.45
	Raichur	20.24	15.81	18.03	12.55	9.82	11.19	8.53	9.52	9.03	33.99	40.06	37.03
	Mean	18.13	18.12	18.12	11.78	11.25	11.51	8.59	9.54	9.06	37.36	38.92	38.14
Andhra Pradesh	Guntur	-	21.84	21.84	-	12.98	12.98	-	11.51	11.51	-	39.80	39.80
	Kurnool	16.81	18.82	17.81	12.69	13.65	13.17	10.55	11.38	10.96	43.90	43.54	43.72
	Mean	16.81	20.33	19.82	12.69	13.31	13.07	10.55	11.44	11.23	43.90	41.67	42.79
Maharashtra	Solapur	19.97	-	19.97	13.77	-	13.77	7.70	-	7.70	35.07	-	35.07
	Mean	19.97	-	19.97	13.77	-	13.77	7.70	-	7.70	35.07	-	35.07

- Not visited

Table 4a : Mean fruit rot and die-back incidence and severity under rainfed and irrigated condition in the survey during 2012-13 and 2013-14

Year	Rain fed					Irrigated				
	Total fields	Fruit rot incidence (%)	Fruit rot PDI	Die-back incidence (%)	Die-back PDI	Total fields	Fruit rot incidence (%)	Fruit rot PDI	Die-back incidence(%)	Die-back PDI
2012-13	145	16.96	11.10	9.20	36.16	210	18.69	12.25	7.54	35.44
2013-14	165	18.37	11.58	10.01	40.03	220	19.23	12.22	9.03	34.11
Mean	155	17.66	11.34	9.60	38.09	215	18.96	12.23	8.28	34.77

Table 4b: Mean fruit rot and die-back incidence and severity in red soil and black soil during the survey during 2012-13 and 2013-14

Year	Red soil					Black soil				
	Total fields	Fruit rot incidence (%)	Fruit rot PDI	Die-back incidence (%)	Die-back PDI	Total fields	Fruit rot incidence(%)	Fruit rot PDI	Die-back incidence(%)	Die-back PDI
2012-13	130	17.97	11.78	8.76	37.30	225	18.10	11.90	9.22	37.85
2013-14	150	18.10	11.90	9.22	37.85	235	19.02	11.86	10.26	40.69
Mean	140	18.03	11.84	8.99	37.57	230	18.56	11.88	9.74	39.27

Table 4c: Mean fruit rot and die-back incidence and severity in sole crop and inter cropping system during the survey during 2012-13 and 2013-14

Year	Sole crop					Inter crop				
	Total fields	Fruit rot incidence (%)	Fruit rot PDI	Die-back incidence (%)	Die-back PDI	Total fields	Fruit rot incidence (%)	Fruit rot PDI	Die-back incidence(%)	Die-back PDI
2012-13	252	18.05	11.81	8.55	35.80	103	17.30	11.44	9.81	38.56
2013-14	284	19.12	12.09	9.54	38.91	101	17.75	11.29	10.40	40.48
Mean	256	18.58	11.95	9.04	37.35	102	17.52	11.36	10.10	39.52

Table 5 : Prevalence of fruit rot and die-back disease in different chilli genotypes in the survey during 2012-13 and 2013-14

	Fruit rot						Dieback					
	Incidence (%)			PDI			Incidence (%)			PDI		
Genotype	2012	2013	Mean	2012	2013	Mean	2012	2013	Mean	2012	2013	Mean
Byadgi Dabbi	18.41	20.61	19.51	11.71	11.89	11.80	9.39	10.01	9.70	36.88	40.67	38.78
Byadgi Kaddi	15.98	15.77	15.88	11.08	11.10	11.09	7.58	8.04	7.81	27.50	30.90	29.20
Dyavanur dabbi	18.55	19.28	18.92	11.02	10.14	10.58	8.11	9.42	8.77	32.51	41.5	37.01
Guntur	18.63	18.79	18.71	12.50	12.17	12.33	8.76	9.14	8.95	32.54	35.36	33.95
Theja	18.54	20.38	19.46	13.45	13.71	13.58	9.45	12.23	10.84	39.62	46.19	42.91
Gadag Local	15.98	20.15	18.06	9.76	12.02	10.89	9.29	10.80	10.05	41.86	43.88	42.87
C-341	10.72	-	10.72	9.1	-	9.1	-	-	-	-	-	-
LCA-960	-	21.88	21.88	-	11.33	11.33	-	9.67	9.67	-	40.13	40.13
G-888	20.25	-	20.25	-	12.22	12.22	-	9.53	9.53	-	42.34	42.34

\- Not visited

Table 6 : Predominance of pathogen/s observed in the survey during 2012-13 and 2013-14

	Per cent Predominance of pathogen/s		
Pathogens	2012	2013	Mean
Cc	7.46	10.81	9.22
Cg	1.49	1.35	1.42
Ca	0.00	0.00	0.00
F	0.00	0.00	0.00
A	0.00	0.00	0.00
Cc + Cg	4.48	4.05	4.26
Cc+ Ca	2.99	4.05	3.55
Cc+ F	28.36	28.38	28.37
Cc+ A	10.45	12.16	11.35
Cg+ Ca	0.00	0.00	0.00
Cg+ F	5.97	5.41	5.67
Cg+ A	5.97	5.41	5.67
Ca+ F	0.00	0.00	0.00
Ca+ A	0.00	0.00	0.00
F+ A	0.00	0.00	0.00
Cc+ Cg+ Ca	0.00	0.00	0.00
Cc + F + A	8.96	5.41	7.09
Cc+ Cg+ F	2.99	1.35	2.13
Cc+ Ca +A	2.99	4.05	3.55
Cg +Ca +F	0.00	0.00	0.00
Cc + Cg +A	10.45	10.81	10.64
Cc +Ca +F	2.99	2.70	2.84
Cg +F +A	1.49	1.35	1.42
Ca +F +A	0.00	0.00	0.00
Ca+Cg+A	0.00	0.00	0.00
Cc+Cg +Ca+F	0.00	0.00	0.00
Cc+Cg+Ca+A	0.00	0.00	0.00
Ca+Cg+F+A	0.00	0.00	0.00
Cc+Ca+F+A	0.00	0.00	0.00
Cc+Cg+F+A	1.49	1.35	1.42
Cc+Ca+Cg+F	0.00	0.00	0.00
Cc+Cg+Ca+F+A	1.49	1.35	1.42

Cc – *Colletotrichum capsici* Cg – *C. gloeosorioides*, Ca – *C. acutatum*, A – *Alternaria* sp., F – *Fusarium* spp.

Table 7 : Frequency of pathogen/s isolated from chilli fruit rot disease

	Frequency (%)		
Pathogens	2012-13	2013-14	Mean frequency (%)
Colletotrichum capsici	37.25	39.87	38.56
C. gloeosporioides	15.68	14.11	14.89
C. accutatum	4.57	5.52	5.04
Fusarium oxysporum	10.17	12.07	11.12
F. sporotrichioides	13.23	9.28	11.25
Alternaria alternata	18.95	19.01	18.98

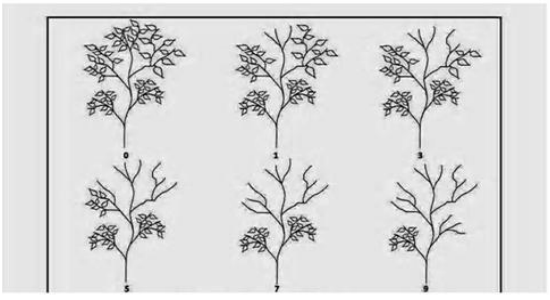

Fig. 1 : Chilli dieback disease rating scale

ity in pathogenic fungi. The mean frequency of pathogens isolated from samples collected during survey recorded as the highest frequency (38.56%) was observed in *C. capsici* followed by *A. alternata* (18.98%) and *C. gloeosporioides* (14.89%) (Table.7). Shivakumara (2006)

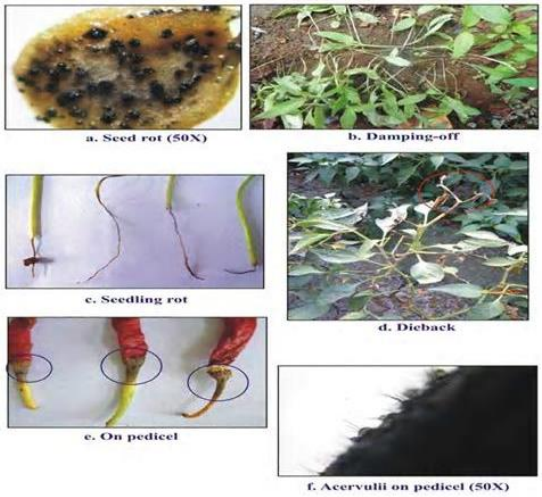

Fig. 2 : Symptoms on seeds, seedling, twigs and pedicel

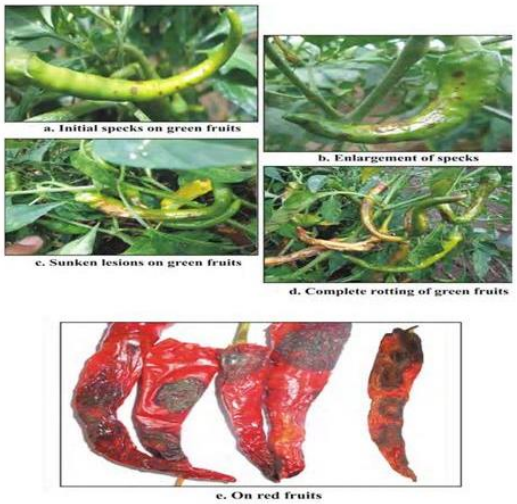

Fig. 3 : Symptoms on fruit

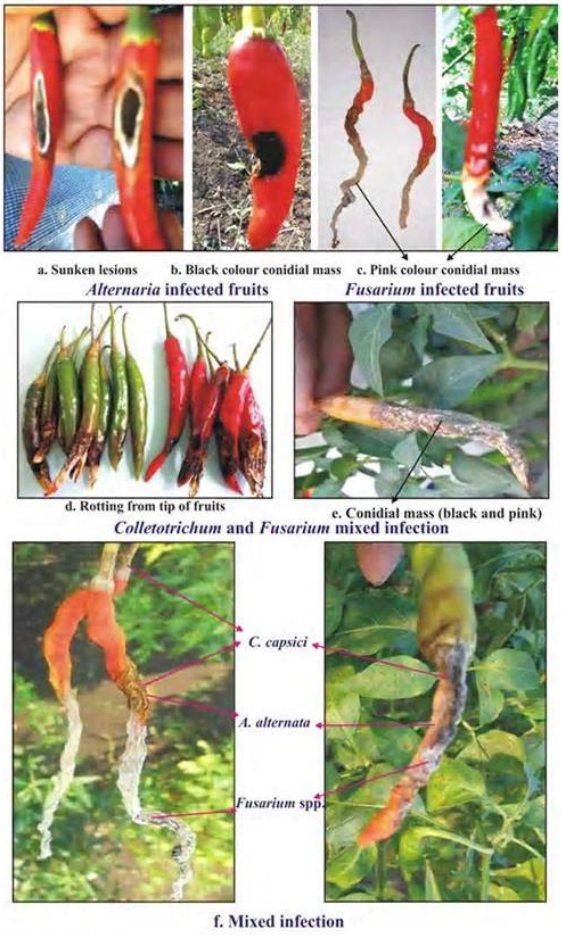

Fig. 4 : Symptoms on fruit

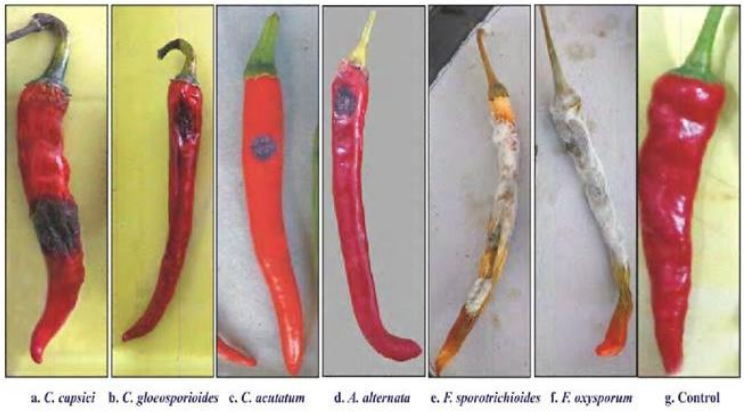

Fig. 5 : Symptoms after pathogenicity test by different fungi and control

isolated *Colletotrichum* spp. (25%) followed by *A. alternata* (21%) from fruit infected chilli from northern Karnataka.

The present results are well supported by the reports of Bagri *et al.* (2004) and Das *et al.* (2004) wherein they reported the maximum prevalence of *Colletotrichum capsici*. In fruit rot disease of chilli, multiple infections were quite common. Many workers have also reported the prevalence of more than two fungal pathogens in fruit rot disease of chilli (Bagri *et al.* 2004).

Pathogenecity test
C.capsici C. gloeosporioides and *C. acutatum*

All three species of *Colletotrichum* caused a depressed sunken, discolored, circular to irregular spots of 5 to 10 mm sizes after two days of inoculation (DAI) on fruit by pin prick method. The spots became black to grey in color after ten DAI. On these discolored lesions salmon colored spore mass was found fifteen DAI. When the diseased fruit was cut open inner surface of the skin was found to be covered with black somatic masses of pathogen (Fig. 5). Seeds were discolored and distinguished from healthy seeds.

A. alternata

Sunken discolored, circular spots of 5 to 10 mm size were observed after two DAI on fruit by pin prick method. Lesions became darker and covered by black moldy growth of fungus was observed at ten DAI. On these lesions heavy sporulation of black color was found on fifteen DAI.

F. oxysporum and *F. sporotrichioides*

Water soaked sunken lesions of 5 to 10 mm size was seen after two DAI on fruit and covered by whitish pink moldy growth of fungus was observed on ten DAI. On these lesions sporulation was found as pink color mass on fifteen DAI.

These all above mentioned reactions of pathogens on fruit after inoculation were found similar to the earlier workers (Shivakumara, 2006; Than *et al.* 2008; Akhtar, *et al.* 2009) report. Santoshreddy *et al.* (2014b) detected *Colletotrichum capsici, C. gloeosporioides, Alternaria alternata, Fusarium* spp. from infected fruits, seeds, pedicel, die-back twigs by molecular PCR based method.

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