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Research Article

A Survey On The Incidence Of Rhizome Rot Disease In Major Turmeric Growing Tracts Of South India And Isolation Of Associated Organisms

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ABSTRACT

A detailed survey on rhizome rot disease of turmeric (*Curcuma longa L.*) was conducted in the major turmeric growing tracts of South India. A total of 37 different locations of Andhra Pradesh, Karnataka, Kerala and Tamil Nadu were covered during the survey. The highest disease incidence was noted in Guntur district of Andhra Pradesh (32.22%) followed by Salem district of Tamil Nadu (20.67%). Among the four states surveyed, three locations in Kerala and Andhra Pradesh recorded no disease incidence (0%). According to the information collected, the highest disease incidence and spread of the disease often coincided with the monsoon season of the respective locations. Differences were noted on the system of cultivation, practices of crop rotation and crop protection strategies among the different locations during the survey. The analysis of rhizome rot samples collected during the survey revealed that *Pythium* is the predominant organism actively involved in the rhizome rot disease. *Rhizoctonia* and *Fusarium* are the other organisms found frequently associated with the infected samples. Out of 118 samples, 74.5% yielded *Pythium* spp., 30.51% yielded *Fusarium* and 28.8% yielded *Rhizoctonia* spp. Some samples yielded a combination of these three organisms. The pathogenicity studies of these isolates may prove the role of these organisms for the exact cause of rhizome rot disease in turmeric.

Key words: *Pythium*, *Rhizoctonia*, *Fusarium*, *Curcuma longa* L., Turmeric, Rhizome rot

INTRODUCTION

Turmeric (*Curcuma longa* L.), known as 'haridra' meaning yellow colored wood in Sanskrit, is a part of Indian delicacies, health care as well as rites and rituals since time immemorial. The anti-oxidant attributes of this spice protect against the high energy free radical damage to organic cells (Maheshwari et al., 2006). The antibacterial, antiviral, antifungal and antiinflammatory properties of this herb appear as an effective cure for several diseases (Negi et al.1999; Kim et al., 2009; Chen et al., 2010; Koosirirat et al., 2010). It is also reported to detoxify the liver, balance cholesterol levels, fight allergies, stimulate digestion, boost immunity and enhance the complexion (Patel and Srinivasan, 1996; Ram et al., 2003; Arafa, 2005). It is one of the important spice crops which play a key role in the national economy of India. India is the major producer and exporter of turmeric in the world (Satishkumar, 2005). The major turmeric importing countries are Bangladesh, Germany, Iran, Japan, Malaysia, South Africa, Singapore, Sri Lanka, UAE and USA (http1). It is cultivated in South and North Eastern states of India in more than 200 districts spread over 25 states. The major production is confined to Andhra Pradesh, Assam, Kerala, Maharashtra, Orissa and Tamil Nadu which accounts for more than 75% of the turmeric produced in the country.

Turmeric is vulnerable to a number of fungal diseases of both soil and air borne nature. Bacterial and viral diseases are not so common. The important diseases affecting the crop are rhizome rot, leaf spot, leaf blotch, leaf blast and leaf blight (Joshi and Sharma, 1980; Ravindran, 2007). Nematode infestations and storage rots are other problems. Among the diseases, rhizome rot is the most destructive one causing enormous economic damage (Rathaiah, 1982). Crop loss up to 50% was reported in Telangana region of Andhra Pradesh where the crop is grown on a large scale. Many fungal pathogens and other organisms have been reported from different turmeric growing tracts associated with the disease (Park, 1934; Sarma et al., 1974; Rathaiah, 1982; Sharma and Roy, 1987; Dohroo, 1988; Anandam et al., 1996; Reddy et al., 2003). The present work was mainly aimed at conducting a detailed survey on the intensity of rhizome rot disease in turmeric in the major growing tracts of South India and also to isolate the organisms associated with disease samples. Collection of information on cultural practices that are being

adopted by the farmers in different locations during cultivation was also a part of the present study.

MATERIALS AND METHODS

Survey for the disease

Survey was conducted during 2006-2009 in the turmeric growing tracts of South India to study the intensity of rhizome rot disease in turmeric. The period of survey included both monsoon and post monsoon seasons. Different locations from four Southern states *viz.*, Andhra Pradesh (present Telangana and Andhra Pradesh), Karnataka, Kerala, and Tamil Nadu were chosen for the survey. A total of 37 different locations in 12 districts of South India were covered. The plants showing symptoms of rhizome rot such as yellowing of the foliage, rotting of the pseudostem, root rot etc. were identified and recorded (Fig. 1b and 1c). The representative samples of infected plants were collected for isolation and identification of pathogen(s) for further studies. Per cent disease incidence was assessed by counting the number of affected plants out of the total plants. A proforma was prepared to collect and record the information on mode of storage of rhizomes, seed treatments, planting time, mulching materials, fertilizer and fungicide application, crop rotation and intercrops and other diseases in turmeric. Disease incidence were analyzed using MSTATC (Version 1.41).

Isolation of organisms

The infected samples collected during the survey were brought to the laboratory and the infected portions including pseudo stem, roots and rhizomes were used for isolation. The infected parts were washed thoroughly with tap water to remove the adhered soil. Small bits cut from the diseased portions along with some healthy portions were surface sterilized with 10% NaOCl or with 75% ethanol for 1-3 min and then washed in three changes of sterile distilled water and transferred onto Potato Dextrose Agar (PDA) in 90mm petriplate. The hyphal tips growing out from the tissue were excised and transferred onto PDA slants for further growth and identification. The cultures were observed microscopically using Nikon Eclipse E600 Trinocular Research Microscope. The fungal isolates were sub cultured from time to time and maintained on PDA slants and also stored in paraffin oil.

RESULTS AND DISCUSSION

Disease incidence (DI) varied considerably among different locations. Among the 10 locations surveyed in Andhra Pradesh, the highest disease incidence was recorded from Vallabhapuram (32.22%) of Guntur district followed by Atmakur (24.33%) and Kunchanapalli (25.67%), while Cheraooru of the same district was found to be free from disease. The initial symptoms of rhizome rot disease was reported to start after one month of planting and the severity of the disease was reported during August-October, when secondary finger rhizome formation starts. In Karnataka, the disease incidence varied from 1.87%-11.00% (Table No. 1). Ainoli (11.00%) showed maximum incidence while Sulepeth showed minimum (1.87%). The disease incidences in other locations were comparatively low. The rhizome rot disease was reported to be high during September-November. In Kerala, the DI ranged from 2.90%-5.56%. No disease incidence was recorded from Vellarikunnu and Vythiri of Wayanad district. The highest DI was reported from Nathamkuni and Kannampully (5.56%) of Palakkad district. Incidence of rhizome rot disease was found to appear during July-September. In Tamil Nadu, DI varied from 4.56-21.0%. The lowest incidence was reported in Jayapalayam (4.56%) and the highest in Mettur (21.00%). In all the districts of Tamil Nadu, the time of appearance of the rhizome rot disease was found to be one month after planting. The severity of the disease was reported to be observed during September- October when the secondary sprout and finger formation starts.

A total of 118 samples collected from different locations were used for the isolation of organisms associated to rhizome rot disease of turmeric. *Pythium* spp., *Fusarium* spp., and *Rhizoctonia* spp. were the major organisms isolated from the infected samples (Table No. 2). Among the organisms isolated, *Pythium* spp. dominated in majority of the diseased samples followed by *Fusarium* spp. and *Rhizoctonia* spp. Out of 118 samples, 74.58% yielded *Pythium* spp., 30.51% yielded *Fusarium* and 26.27% yielded *Rhizoctonia* spp. However, there were some samples which yielded a combination of these three organisms (Table No. 3). Out of total 118 samples, 56 samples (47.46%) showed *Pythium* spp. alone, seven samples (5.93%) *Rhizoctonia* alone and eight samples (6.78%) *Fusarium* alone. Both *Pythium* and *Fusarium* were isolated from 18 samples **(**15.25%), *Pythium* and *Rhizoctonia* from 14 samples (11.86%) and *Fusarium* and *Rhizoctonia* from 10 samples (8.47%) (Table No. 2).

All the samples collected from Kerala yielded *Pythium*. Out of 44 samples collected from Calicut, Palaghat, and Wayanad district of Kerala, *Pythium* was isolated from 42 samples (95.45%) showing its predominance. All the samples from Palaghat and Wayanad yielded *Pythium* spp. Nine out of 44 (20.45%) were *Fusarium* obtained along with *Pythium* spp. and five samples (11.36%) showed the presence of *Rhizoctonia* spp. along with *Pythium* spp. *Pythium* showed more frequency during isolation of the organisms from infected samples. Only one sample from Kalpetta yielded only *Fusarium*.

Samples collected from Andhra Pradesh also showed the dominance of *Pythium* spp. (59.26%). Out of the 27 samples collected from three districts, 12 samples (44.44%) yielded *Pythium* alone. *Fusarium* alone was isolated from two samples (7.41%) whereas *Rhizoctonia* alone was isolated from six samples (22.22%). The other samples yielded a combination of *Pythium* and *Fusarium* (7.41%), *Pythium* and *Rhizoctonia* (7.41%) and *Fusarium* and *Rhizoctonia* (11.11%) (Table No. 2).

In Tamil Nadu also, the isolates from diseased samples were dominated by *Pythium* spp. Out of 27 samples collected from three districts, 19 samples were found to be colonized by *Pythium* spp. (70.37%), 5 samples (18.52%) showed both *Pythium* and *Fusarium* and 3 samples (11.11%) showed *Pythium* and *Rhizoctonia.* One sample each from Arachalur and Kodumudi yielded only *Fusarium* (7.41%) and one sample (3.70%) from Jayapalayam yielded only *Rhizoctonia*. One

sample from Jayapalayam showed both *Fusarium* and *Rhizoctonia* (3.70%) (Table No. 2)

Table No.1: Details of locations and disease incidence

State	District	Time of Collection	Location	Disease incidence	Longitude & Latitude
Kerala	**Calicut**	2005-2009	Peruvannamuzhi	2.88 (09.63)* ijk	75° 49'E 11° 36'N
	Wayanad	Oct 2005	Vaithiri	0.00 (00.00) l	76° 02'E 11° 32'N
			Vellari kunnu	0.00 (00.00) l	76° 02'E 11° 32'N
		Oct 2006	Kalpetta	4.00 (11.30) fghijk	76° 04'E 11° 36'N
			Nathamkuni	5.56 (13.62) fg	76° 10'E 11° 36'N
			S.Bathery	4.00 (11.30) fghijk	76° 15'E 11° 40'N
		Sep 2006	Panayappara	3.66 (10.84) ghijk	76° 32'E 10° 37'N
	Palakkad		Cheramangalam	5.33 (13.34) fgh	76° 32'E 10° 37'N
			Kannampully	5.56 (13.62) fg	76° 32'E 10° 37'N
			Thillenkeri	4.60 (11.91) fghi	76° 32'E 10° 37'N
		Oct 2006	Chitoor	3.56 (10.60) ghijk	76° 44'E 10° 42'N
			Mannayamkkad	2.90 (9.421) ijk	-
			Vilayodi	4.33 (11.86) fghij	76° 45'E 10° 40'N
			Thathamangalam	4.11 (11.59) fghij	76° 42'E 10° 42'N
Tamil Nadu	**Erode**	Nov 2005	Arachalur	10.56 (18.89) e	77° 70'E 11° 16'N
			Kodumudi	12.60 (20.53) e	77° 88'E 11° 07'N
	Coimbatore	Nov 2005	Thondamuthur	11.00 (19.33) e	76° 50'E 10° 58'N
			Jayapalayam	4.56 (12.26) fghi	76° 56'E 10° 57'N
			Annur	20.67 (26.99) c	77° 06'E 11° 03'N
	Salem	Dec 2006	Mettur	21.00 (27.20) c	77° 48'E 11° 47'N
			Kolathur	19.50 (25.90) c	77° 44'E 11° 51'N
Andhra Pradesh	**Guntur**	Jan 2006	Atmakur	24.33 (29.45) b	80° 34'E 16° 25N
			Kunchanapalli	25.67 (30.38) b	80° 37'E 16° 27'N
			Cheraooru	0.00 (00.00) l	80° 16'E 16° 19'N
			Vallabhapuram	32.22 (34.54) a	80° 43'E 16° 21'N
			Munnangi	15.56 (23.21) d	80° 43'E 16° 10'N
	Karimnagar**	Oct 2006	Metpally	10.33 (18.66) e	78° 37'E 18° 50'N
			Korutla	5.56 (13.51) fg	78° 27'E 18° 48'N
			Morthad	10.56 (18.88) e	78° 37'E 16° 27'N
	Nizamabad**		Jagtial	5.00 (12.85) fghi	78° 55'E 18° 47'N
		Oct 2006	Armoor	3.00 (09.91) hijk	78° 16'E 18° 47'N
Karnataka	**Hassan**	Feb 2006	Sakleshpur	3.33 (10.41) ghijk	75° 47'E 12° 56'N
			Ballupet	2.00 (07.63) jkl	75° 88'E 12° 94'N
	Gulbarga	Jan 2007	Chincholi	6.00 (14.05) f	77° 25'E 17° 28'N
			Ainoli	11.00 (19.31) e	77° 44'E 17° 49'N
			Sulepeth	1.87 (06.90) kl	77° 31'E 17° 54'N
	Bidar	Jan 2007	Gornalli	3.33 (10.42) ghijk	77° 52'E 17° 87'N

*:Figures in parenthesis are arc sin transformed values **Now in Telengana

In Karnataka, out of 20 samples, 12 samples (60.0%) yielded *Pythium* of which three samples showed the colonization of *Pythium* alone (20.0%). Three samples yielded both *Pythium* and *Fusarium* (15.0%) whereas four samples yielded both *Pythium* and *Rhizoctonia* (20.0%). The frequency of occurrence of *Fusarium* and *Rhizoctonia* were found to be more in these samples. A total of 5 samples (25.0%) showed the combination of *Fusarium* and *Rhizoctonia*. The overall data showed the dominance of *Pythium* spp (Table No. 2).

Table No. 2 : Sample wise isolation of organisms.

State	District	Locality	No. of Samples Collected	Organisms isolated					
				*Py** + *Fu**	*Py* + *Rhi**	*Fu* + *Rhi*	*Py*	*Fu*	*Rhi*
Kerala	Calicut	Peruvannamuzhi	8	1	1	-	6	-	-
	Palakkad	Panayappara	3	1	1	-	1	-	-
		Cheramangalam	3	-	1	-	2	-	-
		Kannampully	3	1	-	-	2	-	-
		Thillenkeri	3	1	-	-	2	-	-
		Chitoor	3	1	1	-	1	-	-
		Mannayamkkad	2	1	-	-	1	-	-
		Vilayodi	3	1	-	-	2	-	-
		Thathamangalam	3	-	-	-	3	-	-
	Wayanad	Kalpetta	7	1	1	-	4	1	-
		Nathamkuni	3	-	-	-	3	-	-
		Sulthan Bathery	3	-	-	-	2	-	1
Andhra Pradesh	Karimnagar**	Mettupally	2	-	-	-	1	-	1
		Korutla	2	-	-	1	1	-	-
		Morthad	2	-	-	-	1	-	1
		Jagtial	7	1	1	1	2	1	1
	Nizamabad**	Armoor	3	-	1	1	1	-	-
	Guntur	Atmakur	3	-	-	-	1	-	-
		Kunchanapalli	3	-	-	-	2	-	-
		Vallabhapuram	3	1	-	-	2	-	-
		Munnangi	2	-	-	-	1	1	-
Tamil Nadu	Erode	Arachalur	3	-	-	1	1	1	-
		Kodumudi	4	-	-	-	2	1	-
	Coimbatore	Thondamuthur	3	1	-	-	1	-	-
		Jayapalayam	3	-	-	1	1	-	1
		Annur	5	1	-	-	3	1	-
	Salem	Mettur	3	1	1	-	1	-	-
		Kolathur	6	2	2	-	2	-	-
Karnataka	Hassan	Sakleshpur	3	-	-	-	1	1	1
		Ballupet	2	-	-	1	-	1	-
	Gulbarga	Chincholi	4	1	1	1	1	-	-
		Ainoli	5	1	1	1	1	-	1
	Bidar	Gornalli	6	1	2	2	1	-	-
Total			118	18	14	10	56	8	7
Percentage frequency(%)				15.25	11.86	8.47	47.46	6.78	5.93

***Py- Pythium, Fu- Fusarium, Rhi-Rhizoctonia*; **Now in Telengana

The progression of the disease in all the states was correlated with rainfall. The disease was noted only when the newly formed sprouts were infected. This period varied with the different states. This appearance of the disease coincided with the South - West Monsoon in states like Kerala, Tamil Nadu and Andhra Pradesh and North-East Monsoon in Bidar and Gulbarga districts of Karnataka. Shankariah et al. (1991) reported that continuous rain for a week in September induced rhizome rot disease in turmeric. They also reported a positive correlation between continuous rain and rhizome rot occurrence in Nizamabad district of Andhra Pradesh. The survey conducted in these areas shows that the rainfall during finger formation increases the chance of infection. The infected younger tip of the newly formed finger rhizomes and infected young sprouts reinforce this view (Fig.1 d, c and g). Vallabhapuram (32.2%) of Guntur district that showed the highest DI was severely affected by the rainfall received one week before the survey. In Karim nagar and Nizamabad districts of Andhra Pradesh, the severity of the DI was reported to be higher during North- East monsoon. In most cases the symptoms were reported to appear in the initial stages of the crop when seed borne inoculum plays a major role.

For the better understanding of the disease it is very essential to know about the cultivation practices of the crop which in turn will help to manage the disease to certain extent. The details of cultural practices followed during the cultivation of turmeric were collected with the objective of understanding the DI under each cultivation practices. One of the major differences observed in cultivation practices is the use of the raised bed system (Kerala) and ridge and furrow system (Tamil Nadu, Andra Pradesh and Karnataka). In Kerala, where raised bed system is practiced, comparatively less DI was observed. Moreover, since it is a rainfed crop in Kerala, the disease occurrence was found only during the rainy season when soil moisture was high. The bed system is supposed to help the water to drain off easily. In ridge and furrow system, the irrigation sometimes causes flooding increasing the chance of infection irrespective of the season. The information regarding intercrops and mixed crops also help to understand the biology of the pathogen. The intercrops and crop rotation may be helpful in reducing the primary inoculum for the next season. All the farmers included in the survey followed crop rotation and used suitable and traditionally cultivated crops.

Most of the samples at the initial stage of the disease collected showed colonization mainly by *Pythium* spp. showing its significance as the primary causal organism of the disease (Fig.1 e&g). The sample which yielded *Fusarium* alone was at the advanced stage having completely decayed rhizomes with fibrous vascular tissues and was also colonized by maggots (Fig. 1i).

Figure 1. a. Rhizome rot infected field **b.** Initial symptoms of the disease **c.** Advanced stage of the disease **d-f.** Infected rhizomes **g.** Infected young sprout with healthy mother rhizome **h-i.** Advanced stage of infected rhizome colonized by maggots.

Table No. 3: State wise details (%) of isolated organisms.

State	No. of samples	*Pythium* alone	*Pythium* + *Fusarium*	*Pythium* + *Rhizoctonia*	*Fusarium* alone	*Fusarium* + *Rhizoctonia*	*Rhizoctonia alone*
Andhra Pradesh	27	44.44	7.41	7.41	7.41	11.11	11.11
Karnataka	20	20.00	15.00	20.00	10.00	25.00	10.00
Kerala	44	65.90	18.18	11.36	2.27	-	2.27
Tamil Nadu	27	40.74	18.52	11.11	7.40	7.40	3.70

The data revealed that the isolation from samples at the initial stage of the disease increases the frequency of getting *Pythium* spp. This is supported by the reports of Park (1934) and Ramakrishnan and Sowmini (1954). Almost similar isolation frequency of all the three organisms from Jagtial samples can be substantiated by the advanced stage of the infected samples which were colonized by maggots producing foul smell (Fig. 1i). The complete colonization of *Fusarium* in the Munnangi sample might have suppressed the colonization of other fungi and also those which caused earlier infection. In Tamil Nadu, the predominance of *Pythium* may be due to the collection of samples at the initial stage of the disease. The frequency of *Fusarium* and *Rhizoctonia* was found to be more in Kolathur due to the collection at the end of December and at the later stage of the disease. The variation in the frequency of these isolates can be well substantiated by the samples from Hassan district where the sampling was done during first week of February i.e. almost at end of the season. No *Pythium* was isolated from samples which were of completely decayed and in a dry condition. The samples yielded only *Fusarium* and *Rhizoctonia*. In Gulbarga and Bidar samples, the frequencies of these organisms were almost same since the sampling and isolation were made during the second fortnight of January. There are several reports of simultaneous occurrence of *Pythium* and *Rhizoctonia* together associated with disease complexes (Bharadwaj et al., 1988; Chauhan and Patel, 1990; Harvey et al., 2008; Duarte et al., 2007). The collar rot disease of *Brachiaria brizantha* showed colonization of four *Pythium* and one *Rhizoctonia* but the results of the pathogenic tests showed *Pythium periilum* as the main pathogen (Duarte et al., 2007).

Anandam et al. (1996) reported the occurrence of *Fusarium* sp. along with *Pythium* wherein the latter was repeatedly and consistently associated with rotted samples collected from Cuddapah district of Andhra Pradesh which supports the present results. They could prove pathogenicity only with *P. aphanidermatum*. The primary involvement of the maggots in the disease can be excluded since the samples with the initial stages of infection were devoid of maggots. Hence, they are considered as secondary invaders causing the aggravation of the disease. This is in accordance with the findings of Premkumar et al. (1982) and Koya (1990). They concluded that soft rot is primarily caused by *Pythium* species and dipteran maggots play only a secondary role of putrefying the rotten tissues. The absence of required mouth parts for dipteran maggots to penetrate the rhizome or root support their view of the role of maggots in the disease. The diseased rhizome samples at the initial stages of infection showed no plant parasitic nematodes. Only the diseased samples at advanced stage showed infestation of saprophytic nematodes showing their little role in the initiation of the disease. The secondary invasion by maggots and nematodes highlights the importance of collection of the diseased samples at the exact stage of the disease. Therefore it can be concluded that the maggots and nematodes are not primary causative organisms but are secondary invaders at the progress of the disease. Garcia and Mitchell (1975) reported the synergistic interaction between *Pythium myriotylum, Fusarium solani* and *Meloidogyne arenaria* in pod-rot of peanut.

The present study shows that the incidence of rhizome rot disease coincides with the higher moisture retention in soil during the rain fall or irrigation which is also the congenial condition for the proliferation of *Pythium* spp. The samples at the earlier stage of the disease only yield *Pythium* at high frequency. The samples yield other organisms at their advanced stages. The pathogenicity study of these organisms isolated from infected samples will help to elucidate the etiology of the rhizome rot disease in turmeric. The follow up of the present study is to prove the pathogenicity of these isolates to find the actual cause of the disease to develop crop protection measures for the better management of the disease.

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