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Survey for the incidence of wilt of pomegranate in major pomegranate growing district of Karnataka

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Abstract

A survey was carried out in major pomegranate growing districts of Karnataka to know the incidence of wilt during 2015-16, which revealed that among the villages of different district surveyed the highest mean incidence (45.80%) of pomegranate wilt was noticed in Govindkoppa village followed by Kaladgi village (27.05%) in the Bagalkot taluk of Bagalkot district and the least disease incidence (1.00%) was noticed in the Bajjapanhatii village of Hosadurga taluku, Chitradurga district. Among the taluks, the highest mean incidence of wilt (19.93%) was recorded in the Bagalkot taluk of Bagalkot district followed by Vijayapura taluk (9.27%) of Vijayapura district. The lowest incidence of pomegranate wilt (3.20%) was recorded in the Indi taluk of Vijayapura district. Among the districts, the highest mean incidence of wilt (15.27%) was recorded in Bagalkot district followed by Vijayapura district (6.23%). The lowest incidence of pomegranate wilt (3.75%) was recorded in Chitradurga district. Orchards of four years and above old planted under black soil showed higher incidence of wilt along with shot hole borer and root knot nematode infection. Among the soil parameters electrical conductivity of soil showed the significant positive correlation with per cent disease incidence.

Keywords: Survey, wilt, pomegranate, *Ceratocystis fimbriata*

1. Introduction

Pomegranate (*Punica granatum* L.) is an ancient fruit, belonging to the botanical family Lythraceae. Pomegranate is an important fruit crop grown in the dry regions of India. It is also cultivated to a large extent in the northern dry districts of Karnataka state. It is one of the most adaptable subtropical minor fruit crops and its cultivation is increasing very rapidly. The fruit is very much liked for its cool and refreshing juice. The arils of the well matured fruit are consumed as such and also in processed form like juice or concentrate, syrup and jelly. Seeds with fleshy portions of sour pomegranates are dried and marketed as 'Anardana', which is used as a condiment and for souring curries. Wine can be prepared of this fruit as it ferments very easily. The most popular varieties suitable for processing and table use are Ganesh, Mridula, Arakta, Bhagwa, Kesar, G-137 and Khandar. Area under pomegranate is increasing worldwide because of its hardy nature, wider adaptability, drought tolerance, higher yield levels, excellent keeping quality and remunerative prices in domestic as well as export markets. It thrives well in the dry tropics and sub-tropics and comes up very well in soils of low fertility status, adding to that it is salt tolerant too.

In India, it is regarded as a "vital cash crop", grown in an area of 143 thousand ha with a production of 1774 thousand tonnes with an average productivity of 10.75 tonnes/ha (Anon., 2015). Among the different states growing pomegranate, Maharashtra is the largest producer occupying 2/3rd of total area in the country followed by Karnataka, Andhra Pradesh, Gujarat and Rajasthan. Karnataka state has the distribution of cultivating pomegranate under tropical condition in an area of 19.04 thousand hectare with a production of 204.64 thousand tonnes and productivity 10.75 tons per hectare (Anon., 2015). Where this crop has spread across different districts of Karnataka, the major districts come under cultivation are Chitradurga, Vijayapura, Bellary, Koppal and Bagalkot with an area of 6.31, 1.53, 1.70, 1.68, 1.36 thousand hectare and production of 40.68, 15.25, 15.00, 14.03, 10.44 tonnes per hectare respectively [1]. Successful cultivation of pomegranate in recent years has met with different traumas such as pest and diseases. Among the diseases wilt caused by *Ceratocystis fimbriata* Ellis and Halst. is a major threat. At present, the crop is severely affected by wilt pathogen and day by day the disease is increasing at a faster rate.

Hence the present investigation was under taken to assess the disease incidence and also to know the severity with respect to locality and cultivar and also the influence of soil parameters on disease incidence in major pomegranate growing districts of Karnataka.

Materials and Methods

To assess the extent of wilt disease severity, the intensive roving survey was conducted during *kharif* 2015 and 2016 in important pomegranate growing districts of northern Karnataka. In each district major pomegranate growing taluks were selected, in each village five fields were randomly selected. Samples of soil and roots were collected from sufficiently wet fields from the rhizosphere of the pomegranate crop to the root depth. The per cent disease incidence was calculated using the following formula

$$\text{Per cent disease incidence} = \frac{\text{No. of plants showing wilting symptom}}{\text{Total number of plants}} \times 100$$

Each soil sample was filled in a polythene bag and tied with a rubber band and labeled immediately. Information pertaining to the locality, crop history, etc. was also labeled along with the samples. Samples of soil and roots were analysed on the day of collection or after keeping for a few days under refrigerated conditions.

Soil sample analysis

Soil samples collected during the survey were analyzed for the parameters like EC, pH and bulk density

Soil sample analysis for Electric conductivity (EC)

Soil samples were sieved by passing through 2 mm mesh sieve and 20 g of soil was weighed from each sample separately and added to 100 ml beaker. For each sample 50 ml of distilled water was added and mixed thoroughly by using a glass rod. The samples were left over night to make the soil particles to settle down and with the help of EC meter the observations were recorded.

Soil sample analysis for pH

Soil samples were sieved by passing through 2 mm mesh sieve and 20 g of soil was weighed from each sample separately and added to 100 ml beaker. For each sample 50 ml of distilled water was added and mixed thoroughly by using a glass rod. The pH of the soil was recorded after calibrating pH meter with the standard buffers

Soil sample analysis of bulk density

Bulk density of the soil was done by tapping cylinder method. The soil samples were sieved by passing through 2 mm mesh sieve and 50 g of soil was taken into 100ml graduated cylinder. Gentle tap was given at the base of the cylinder on a slightly resilient surface until to the height of the sample is compactly fixed in the cylinder i.e the sample height does not reduce with further tapping. The bulk density of soil was calculated by using the formula

$$\text{Bulk density} = \frac{m}{V}$$

m = mass of sample in g, V = volume of sample in cc (ml)

Correlation coefficient

The data on per cent disease incidence recorded during the

survey and soils collected from respective fields were analyzed. PDI was subjected to correlation analysis with different soil parameters, and the correlation coefficient thus obtained was compared to their significant following the method described by [2].

Results and Discussion

A roving survey was carried out in major pomegranate growing districts of Karnataka viz., Bagalkot, Ballari, Chitradurga, Koppal and Vijayapura during 2015-16 to find out the prevalence of wilt in pomegranate. The pomegranate growing areas in the above mentioned districts were surveyed as explained in "Material and Methods" and the data are presented in Table 1. The survey maps are prepared by using latitude and longitude of the field in Google Earth software 2016 and presented in Plate 1.

Survey conducted in Bagalkot district indicated that, the mean incidence of pomegranate wilt was 15.27 per cent (Table 1). The highest incidence of pomegranate wilt (19.93%) was observed in Bagalkot taluk followed by Badami taluk (10.61%). Among the villages of Bagalkot taluk, Govindkoppa village recorded the highest pomegranate wilt (45.80%) followed by Kaladgi village (27.05%) and lowest disease incidence was noticed in the Tulasigere village (2.53%). Kerkalmatti village of Badami taluk recorded the highest wilt incidence (19.82%) followed by Sulikeri village (6.25%) and the lowest disease incidence was recorded in the Yandigere village (3.58%). Per cent root knot and shot hole borer infection was recorded in wilted plants. In Bagalkot taluk per cent root knot infection was ranged from 0.00 to 77.77 per cent, whereas, in Badami taluk it ranged from 0.00 to 50.00 per cent. Shot hole borer infection ranged between 0.00 to 40.00 per cent, while in Badami taluk it has been recorded from 0.00 to 50.00 per cent.

The average disease incidence in Ballari district was 4.89 per cent (Table 1). Maximum incidence (6.18%) was observed in Ballari taluk followed by HB Halli taluk (3.60%). Among the villages, Lakshmipura village of Ballari taluk recorded highest incidence (10.20%) followed by Karikeri village (4.83%) and least disease incidence was observed in the Kallukamba village (1.5%). Hampasagara village of HB Halli taluk recorded highest disease incidence (5.58%) followed by Gaddikeri village (4.57%) and least disease incidence was recorded in the Bannikallu village (1.87%). Per cent root knot infection in Ballari taluk recoded from 0.00 to 77.77 per cent, while shot hole borer recorded from 0.00 to 45.45 per cent. HB halli recorded between 0.00 to 80.00 per cent of root knot infection in wilted plants, whereas shot hole borer recorded from 0.00 to 40.00 per cent.

Chitradurga district is well known for pomegranate cultivation and highest pomegranate wilt of 3.75 per cent incidence was recorded in the district. The maximum incidence (3.58%) was observed in Hosadurga taluk followed by Hiriyur taluk (3.29%). Uralihalli village of Hosadurga taluk noticed the highest incidence of wilt (9.40%) followed by Gollarhatti village (2.42%) and least disease incidence was observed in Bajjappanhatti (1.00%). Among Hiriyur taluk villages, Muscaltatti village observed the highest incidence (4.98%) followed by Haleyalanadu village (4.67%) and the lowest disease incidence was recorded in the Benakanhalli village (1.83%). Root knot infection in Hiriyur taluk ranged from 0.00 to 57.14 per cent, while shot hole borer ranged from 0.00 to 42.85 per cent. In Hosadurga taluk per cent root knot infection was recorded from 0.00 to 55.55, whereas shot hole borer recorded from 0.00 to 45.45 per cent.

Table 1: Incidence of wilt of pomegranate in major pomegranate growing districts of Karnataka during 2015-2016.

Sl. No	Name of the place			Latitude	Longitude	Age of the crop (years)	Soil type	Variety	Per cent shot hole borer infection in wilted plants	Per cent root knot infection in wilted plants	Wilt incidence (%)	Average wilt incidence		
	District	Taluk	Village											
1	Bagalkot	Badami	Kerkalmatti	75.335771	16.080931	5	Red soil	Bhagwa	50.00	0.00	37.50	19.82		
			Kerkalmatti	75.321377	16.074416	3	Red soil	Bhagwa	0.00	33.33	2.14			
			Sulikeri	75.383147	16.073665	4	Red soil	Bhagwa	0.00	40.00	6.25	6.25		
			Yandigere	75.283716	16.084510	4	Red soil	Bhagwa	25.00	37.50	3.04	3.58		
			Yandigere	75.283480	16.082807	6	Red soil	Bhagwa	40.00	50.00	4.12			
		Taluk Mean											10.61	9.88
		Bagalkot	Chikksansi	75.320789	16.135216	3	Black soil	Bhagwa	0.00	62.50	6.40	4.35		
			Chikksansi	75.321270	16.135216	4	Black soil	Bhagwa	0.00	46.15	4.76			
			Chikksansi	75.320867	16.125886	3	Black soil	Bhagwa	0.00	28.57	1.90			
			Govindakoppa	75.314298	16.120447	3	Red soil	Ruby	0.00	66.66	25.00	45.80		
			Govindakoppa	75.311990	16.111976	6	Black soil	Bhagwa	0.00	53.33	75.00			
			Govindakoppa	75.312114	16.111967	4	Black soil	Bhagwa	0.00	60.00	81.25			
			Govindakoppa	75.311803	16.111505	5	Black soil	Bhagwa	0.00	36.36	2.22			
			Kaladgi	75.293438	16.123848	4	Black soil	Bhagwa	37.50	0.00	8.26	27.05		
			Kaladgi	75.292611	16.124063	7	Black soil	Bhagwa	21.42	0.00	80.00			
			Kaladgi	75.292766	16.132537	6	Black soil	Bhagwa	0.00	64.70	16.43			
			Kaladgi	75.304144	16.121826	7	Black soil	Bhagwa	30.00	50.00	3.51			
			Sokanadgi	75.345254	16.133677	5	Red soil	Bhagwa	0.00	53.84	4.16	4.16		
			Tulasigere	75.321013	16.115993	3	Red soil	Bhagwa	0.00	50.00	1.92	2.53		
			Tulasigere	75.320246	16.115719	1 ½	Red soil	Ruby	0.00	75.00	3.19			
			Tulasigere	75.314820	16.120272	2	Red soil	Super bhagwa	40.00	0.00	1.26			
		Tulasigere	75.332692	16.114241	5	Red gravel	Bhagwa	-	77.77	3.75				
		Taluk Mean											19.93	16.77
District Mean											15.27	13.32		

Cont....

Sl. No	Name of the place			Latitude	Longitude	Age of the crop (years)	Soil type	Variety	Per cent shot hole borer infection in wilted plants	Per cent root knot infection in wilted plants	Wilt incidence (%)	Average wilt incidence
	District	Taluk	Village									
2	Ballari	Ballari	Kallukamba	76.463670	15.204381	4	Red sandy	Bhagwa	0.00	00.00	1.61	1.5
			Kallukamba	76.462201	15.205147	2	Red loamy	Bhagwa	0.00	00.00	1.39	
			Karikeri	76.465850	15.214754	5	Red loamy	Bhagwa	0.00	50.00	7.96	4.83
			Karikeri	76.465095	15.215463	5	Red sandy	Bhagwa	20.00	40.00	1.71	
			Lakshmipura	76.474538	15.201552	4	Red loamy	Bhagwa	0.00	53.84	20.32	10.20

		Lakshmipura	76.474855	15.201721	6	Red loamy	Bhagwa	0.00	77.77	6.81	
		Lakshmipura	76.480359	15.201500	10	Red loamy	Bhagwa	45.45	45.45	3.47	
	Taluk Mean									6.18	5.51
	HB Halli	Bannikallu	76.031355	15.054211	7	Red loamy	Bhagwa	0.00	25.00	1.53	1.87
		Bannikallu	76.044253	15.041818	4	Red loamy	Bhagwa	0.00	50.00	2.44	
		Bannikallu	76.030177	15.054018	3	Red loamy	Bhagwa	20.00	28.75	1.64	
		Byasigaderi	76.085367	15.030327	6	Red loamy	Bhagwa	0.00	00.00	4.06	4.06
		Gaddikeri	76.051926	15.042186	6	Red loamy	Bhagwa	33.33	00.00	4.57	4.57
		Hampasagara	76.012095	15.064393	4	Red sandy	Bhagwa	0.00	80.00	8.04	5.58
		Hampasagara	76.024981	15.064831	5	Red loamy	Bhagwa	40.00	66.66	3.12	
	Taluk Mean									3.60	4.02
	District Mean									4.89	4.76

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Sl. No	Name of the place			Latitude	Longitude	Age of the crop (years)	Soil type	Variety	Per cent shot hole borer infection in wilted plants	Per cent root knot infection in wilted plants	Wilt incidence (%)	Average wilt incidence
	District	Taluk	Village									
3	Chitradurga	Hiriyur	Benakanhalli	76.522489	14.021642	3	Red sandy soil	Bhagwa	42.85	57.14	1.83	1.83
			Haleyalanadu	76.403598	13.575569	6	Red soil	Bhagwa	40.00	0.00	1.66	4.67
			Haleyalanadu	76.404129	13.575352	5	Red soil	Bhagwa	28.57	0.00	7.69	
			Hosayalanadu	76.401846	13.581429	5	Red soil	Bhagwa	0.00	0.00	4.33	4.33
			Muscalmatti	76.414776	13.594266	10	Red soil	Bhagwa	0.00	45.45	7.69	4.98
			Muscalmatti	76.415336	13.594453	10	Red soil	Bhagwa	0.00	25.00	2.28	
			Vasanthnagar	76.341843	13.523019	2	Red soil	Bhagwa	0.00	20.00	2.00	2.00
		Taluk Mean									3.29	3.56
		Hosadurga	Bajjappanhatti	76.177134	13.483931	6	Red sandy soil	Bhagwa	0.00	55.55	1.00	1.00
			Golarhatti	76.162055	13.564779	5	Red soil	Bhagwa	0.00	0.00	1.92	2.42
			Golarhatti	76.163385	13.555052	6	Red soil	Bhagwa	0.00	25.00	2.93	
			Honekere	76.140552	13.482487	3	Red soil	Bhagwa	0.00	36.36	1.78	1.78
			Kurubhanhalli	76.185460	13.474957	3	Red soil	Bhagwa	45.45	0.00	3.96	2.33
			Kurubhanhalli	76.190591	13.475279	5	Red soil	Bhagwa	0.00	16.66	0.71	
			Mavinkatte	76.133435	13.542424	4	Red soil	Bhagwa	0.00	42.85	1.19	1.19
			Uralihalli	76.190882	13.430552	7	Red soil	Bhagwa	20.00	40.00	2.81	9.40
		Uralihalli	76.184847	13.425924	5	Red soil	Bhagwa	30.67	53.84	16.00		
		Taluk Mean									3.58	3.02
		District Mean									3.75	3.29

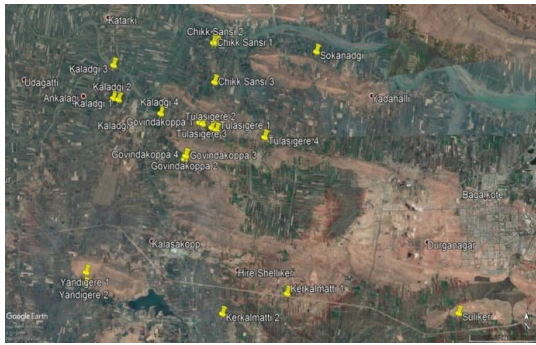
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Sl. No	Name of the place			Latitude	Longitude	Age of the crop (years)	Soil type	Variety	Per cent shot hole borer infection in wilted plants	Per cent root knot infection in wilted plants	Wilt incidence (%)	Average wilt incidence	
	District	Taluk	Village										
4	Koppal	Kushtagi	Hanamsagar	76.031144	15.511176	7	Red loamy	Bhagwa	0.00	61.53	5.28	7.26	
			Hanamsagar	76.025869	15.504832	5	Red loamy	Bhagwa	0.00	73.33	12.69		
			Hanamsagar	76.030943	15.505510	8	Red loamy	Bhagwa	0.00	42.85	3.83		
			Kabbargi	75.581184	15.553696	5	Red loamy	Bhagwa	0.00	50.00	7.15	7.15	
			Katapura	75.595197	15.571139	4	Red sandy	Bhagwa	50.00	0.00	1.69	1.84	
			Katapura	75.575809	15.573041	2	Red loamy	Bhagwa	0.00	0.00	2.00		
			Mavinaitagi	76.012264	15.515041	4	Red loamy	Bhagwa	30.00	0.00	2.66	2.66	
		Taluk Mean										5.04	4.72
		Yelburga	Bevoor	76.100601	15.343257	6	Red loamy	Bhagwa	0.00	42.85	2.04	1.58	
			Bevoor	76.100587	15.343655	4	Red sandy	Bhagwa	0.00	20.00	1.12		
			Kalakbandi	76.073918	15.412121	7	Red loamy	Bhagwa	40.00	40.00	2.40	6.33	
			Kalakbandi	76.072216	15.412738	8	Red loamy	Bhagwa	0.00	0.00	10.62		
			Mandalhari	76.102789	15.393197	5	Red loamy	Bhagwa	41.66	0.00	6.00	5.43	
			Mandalhari	76.065278	15.391096	4	Red loamy	Bhagwa	46.66	0.00	4.87		
			Murdi	76.101359	15.365272	3	Red loamy	Bhagwa	0.00	50.00	4.06	4.11	
			Murdi	76.091455	15.370167	5	Red sandy	Bhagwa	0.00	41.66	4.16		
Taluk Mean										4.40	4.36		
District Mean										4.72	4.54		

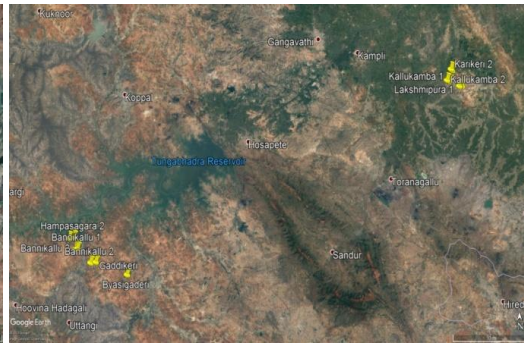
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Sl. No	Name of the place			Latitude	Longitude	Age of the crop (years)	Soil type	Variety	Per cent shot hole borer infection in wilted plants	Per cent root knot infection in wilted plants	Wilt incidence (%)	Average wilt incidence	
	District	Taluk	Village										
5	Vijayapura	Indi	Atharga	75.530313	16.585901	6	Black soil	Bhagwa	0.00	0.00	3.36	3.15	
			Atharga	75.523218	16.591922	2	Black soil	Bhagwa	0.00	0.00	3.20		
			Atharga	75.524149	17.003001	5	Black soil	Bhagwa	40.00	0.00	2.46		
			Atharga	75.521791	16.592325	5	Black soil	Bhagwa	20.00	53.33	4.37		
			Atharga	75.524203	16.585040	6	Black soil	Bhagwa	40.00	40.00	2.40		
			Gornal	75.593788	17.025311	4	Black soil	Bhagwa	50.00	60.00	4.76	2.40	
			Tadavalga	75.550062	17.044704	2	Black soil	Bhagwa	0.00	40.00	1.90	1.90	
		Taluk Mean										3.20	2.48
		Vijayapura	Aliyabad	75.473154	16.534076	5	Black soil	Bhagwa	0.00	86.66	33.33	23.78	
			Aliyabad	75.478526	16.539307	4	Black soil	Bhagwa	46.15	0.00	14.23		
Jambagi	75.530602		16.552145	6	Black soil	Bhagwa	0.00	50.00	3.06	3.59			

Jambagi	75.545138	16.543409	6	Black soil	Bhagwa	0.00	50.00	4.16	5.54	
Jambagi	75.550703	16.541650	4	Black soil	Bhagwa	0.00	40.00	3.04		
Jambagi	75.545141	16.545141	4	Black soil	Bhagwa	0.00	58.33	4.12		
Jumnal	75.432185	16.445485	10	Black soil	Bhagwa	46.66	93.33	8.33		
Jumnal	75.431133	16.441790	4	Black soil	Bhagwa	50.00	0.00	3.33		
Jumnal	75.432386	16.441148	2	Black soil	Bhagwa	16.66	0.00	1.61		
Jumnal	75.4333.37	16.424736	6	Black soil	Bhagwa	0.00	40.00	3.00		
Jumnal	75.433445	16.435600	4	Black soil	Bhagwa	0.00	66.66	11.44		
Nagathan	75.491832	16.544673	4	Black soil	Bhagwa	0.00	80.00	16.66		12.37
Nagathan	75.497100	16.552754	3	Black soil	Bhagwa	35.29	76.47	27.27		
Nagathan	75.494250	16.551655	3	Black soil	Bhagwa	40.00	70.00	4.00		
Nagathan	75.494354	16.551805	4	Black soil	Bhagwa	25.00	0.00	1.58		
Taluk Mean							9.27	10.42		
District Mean							6.23	6.45		



Bagalkot District



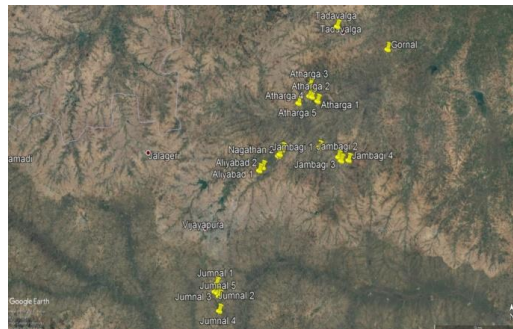
Ballari District



Chitradurga District



Koppal District



Vijayapura District

Plate 1: Yellow points on different district maps indicate the GPS locations of the pomegranate fields visited during the survey.

Table 1a: Incidence of wilt, shot hole borer and root knot infection of pomegranate in relation to age of the crop and soil type

Sl. No	Age of the crop	Average wilt incidence (%)	Average per cent shot hole borer infection in wilted plants	Average per cent root knot infection in wilted plants
1	Up to 3 years	4.92	12.01	34.74
2	4-6 years	8.97	14.26	35.44
3	Above 7 years	10.97	16.96	39.05
Soil type				
1	Red soil	5.20	14.11	34.55
2	Black soil	13.80	16.08	40.65

Table 2: Soil parameters and wilt incidence in the area surveyed

Sl. No.	Name of the location			EC (mS/m)	pH	Bulk density (g/cc)	PDI*
	District	Taluk	Village				
1	Bagalkot	Badami	Kerkalmatti	0.13	8.14	1.13	37.50
			Kerkalmatti	0.63	8.95	1.00	2.14
			Sulikeri	0.84	8.26	0.41	6.25
			Yandigere	0.60	6.98	0.92	3.04
			Yandigere	1.68	8.05	1.06	4.12
		Bagalkot	Chikksansi	0.35	8.51	1.28	6.40
			Chikksansi	1.90	7.84	1.21	4.76
			Chikksansi	0.39	8.51	1.28	1.90
			Govindakoppa	0.25	8.16	1.13	25.00
			Govindakoppa	0.60	8.10	1.11	75.00
			Govindakoppa	0.72	7.91	0.98	81.25
			Govindakoppa	0.42	8.23	1.13	2.22
			Kaladgi	1.42	7.62	1.00	8.26
			Kaladgi	1.86	8.38	1.00	80.00
			Kaladgi	1.18	8.26	1.25	16.43
			Kaladgi	0.25	8.27	1.16	3.51
			Sokanadgi	0.50	8.17	1.11	4.16
			Tulasigere	0.12	9.12	1.16	1.92
			Tulasigere	0.33	8.79	1.02	3.19
			Tulasigere	0.14	8.66	1.11	1.26
Tulasigere	0.57	7.89	1.02	3.75			
2	Ballari	Ballari	Kallukamba	0.18	8.36	1.21	1.61
			Kallukamba	0.47	7.83	1.16	1.39
			Karikeri	0.29	8.35	1.25	7.96
			Karikeri	0.13	8.19	1.28	1.71
			Lakshnipura	0.26	8.60	1.16	20.32
			Lakshnipura	0.27	7.69	1.19	6.81
		HB Halli	Lakshnipura	0.23	7.27	1.19	3.47
			Bannikallu	0.52	8.23	1.16	1.53
			Bannikallu	0.36	8.23	1.27	2.44
			Bannikallu	0.91	8.61	1.06	1.64
			Byasigaderi	0.48	8.24	1.11	4.06
			Gaddikeri	0.37	8.10	1.13	4.57
			Hampasagara	0.78	7.90	1.07	8.04
			Hampasagara	0.34	8.40	1.13	3.12
3	Chitradurga	Hiriyur	Benakanhalli	0.14	7.76	1.28	1.83
			Haleyalanadu	0.20	9.15	1.21	1.66
			Haleyalanadu	0.30	8.93	1.19	7.69
			Hosayalanadu	0.10	7.79	1.21	4.33
			Muscalmatti	0.18	8.10	1.25	7.69
			Muscalmatti	0.13	9.06	1.16	2.28
			Vasanthnagar	0.33	8.50	1.02	2.00

Cont....

Sl. No	Name of the location			EC (mS/m)	pH	Bulk density (g/cc)	PDI*
	District	Taluk	Village				
	Chitradurga	Hosadurga	Bajjapanhatti	0.14	7.93	1.31	1.00
			Golarhatti	0.08	9.01	1.38	1.92
			Golarhatti	0.41	7.99	1.16	2.93
			Honekere	0.21	8.10	1.15	1.78
			Kurubhanhalli	0.11	8.41	1.28	3.96
			Kurubhanhalli	0.14	7.83	1.08	0.71
			Mavinkatte	0.13	8.51	1.31	1.19
			Uralihalli	0.16	8.36	1.16	2.81
Uralihalli	0.28	7.88	1.11	16.00			

4	Koppala	Kushtagi	Hanamsagar	0.23	8.29	1.21	5.28
			Hanamsagar	0.10	7.85	1.21	12.69
			Hanamsagar	0.22	8.00	1.25	3.83
			Kabbargi	0.39	7.93	1.13	7.15
			Katapura	0.16	8.34	1.12	1.69
			Katapura	0.24	7.97	1.08	2.00
			Mavinaitagi	0.65	7.68	1.04	2.66
		Yelburga	Bevoor	0.36	8.27	1.11	2.04
			Bevoor	0.22	7.51	1.03	1.12
			Kalakbandi	0.34	7.89	1.12	2.40
			Kalakbandi	0.63	7.87	1.16	10.62
			Mandalhari	0.28	8.16	1.06	6.00
			Mandalhari	0.58	8.03	1.19	4.87
			Murdi	0.18	7.62	1.07	4.06
5	Vijayapura	Indi	Atharga	0.86	8.33	1.20	3.36
			Atharga	0.69	8.01	0.91	3.20
			Atharga	0.56	8.67	1.07	2.46
			Atharga	1.33	8.12	0.78	4.37
			Atharga	0.23	8.76	0.94	2.40
			Gornal	0.15	8.60	0.96	4.76
			Tadavalga	0.20	8.45	0.96	1.90
		Vijayapura	Aliyabad	0.47	7.63	1.08	33.33
			Aliyabad	0.13	8.67	1.38	14.23
			Jambagi	0.53	8.46	1.04	3.06
			Jambagi	0.22	7.81	1.16	4.16
			Jambagi	0.18	8.02	1.12	3.04
			Jambagi	0.24	8.13	1.06	4.12
			Jumnal	0.22	8.63	1.04	8.33
			Jumnal	0.09	8.63	0.92	3.33
			Jumnal	0.29	8.51	1.00	1.61
			Jumnal	0.13	8.63	1.00	3.00
			Jumnal	0.25	8.88	1.00	11.44
			Nagathan	0.27	8.46	1.00	16.66
			Nagathan	0.32	8.77	1.06	27.27
Nagathan	0.31	8.45	1.04	4.00			
Nagathan	0.26	7.53	1.21	1.58			

Table 3: The correlation matrix of different soil parameters on per cent disease incidence of *Ceratocystis fimbriata*

Soil Parameters	EC	pH	Bulk density	Per cent disease incidence
EC	1.00	-0.175	-0.306*	0.302*
pH		1.00	0.017	-0.042
Bulk density			1.00	-0.112
Per cent disease incidence				1.00

*Significant at p=0.05

With respect to Koppal district, results revealed that, the highest pomegranate wilt (5.04%) was found in Kushtagi taluk followed by Yelburga taluk (4.40%). Hanamsagar village of Kushtagi taluk recorded the highest wilt incidence (7.26%) followed by Kabbargi village (7.15%) and the lowest wilt incidence was noticed in Katapura (1.84%). Among villages of Yelburga taluk, Kalakbandi village recorded the highest wilt incidence of 6.51 per cent followed by Mandalhari village (5.43%) and the lowest disease incidence was recorded in Bevoor village (1.58%). The mean incidence in Koppal district for pomegranate wilt was 4.72 per cent. Per cent root knot and shot hole borer infection was ranged from 0.00 to 77.33 and 0.00 to 50.00 per cent, respectively in Kushtagi taluk, while Yelburga taluk recorded 0.00 to 50.00 and 0.00 to 46.66 per cent of root knot and shot hole borer infection, respectively (Table 1).

Vijayapura district recorded the mean pomegranate wilt incidence of 6.23 per cent (Table 1). In the district, highest pomegranate wilt (9.27%) was recorded in Vijayapura taluk followed by Indi (3.20%). Among the villages surveyed in Vijayapura taluk the highest average wilt incidence was

recorded in the Aliyabad village (23.78%) followed by Nagathan (12.37%) and the lowest disease incidence was recorded in Jambagi village (3.59%). In Indi taluk villages, the highest disease incidence was noticed in Gornal (4.76%) followed by Atharga village (3.15%) and least disease incidence was noticed in the Tadavalga village (1.90%). In Vijayapura taluk per cent root knot infection ranged from 0.00 to 93.33 per cent. Shot hole borer infection ranged between 0.00 to 50.00 per cent, while in Indi taluk it has been recorded from 0.00 to 60.00 per cent and shot hole borer recorded 0.00 to 50.00 per cent.

The Table 1a revealed that the average per cent disease incidence of wilt of pomegranate, shot hole borer and root knot infection was 4.92, 12.01 and 34.74 up to 3 years age of the crop respectively. The higher wilt incidence, shot hole borer and root knot infection was recorded in 4-6 years (8.97, 14.26 and 35.44%) and above 7 years (10.97, 16.96 and 39.05%) age of the crop respectively. The higher wilt incidence, shot hole borer and root knot infection was recorded in black soil (13.80, 16.08 and 40.65%) compared to red soil (5.20, 14.11 and 34.44%).

An intensive roving survey was carried out in five districts of Karnataka, viz. Bagalkot, Ballari, Chitradurga, Koppal and Vijayapura during 2015-16 to know the disease incidence of wilt caused by *C. fimbriata* in pomegranate. The data on survey revealed that, the wilt incidence varied from locality to locality, type of cropping pattern and environmental condition. The overall mean incidence of pomegranate wilt in major growing district was recorded 6.97 per cent on different cultivars such as Bhagwa, Ruby and Super Bhagwa grown in Karnataka state. This may be due to buildup of inoculum in the soil prevailed due to continuous cultivation of the crop year after year at different locations [6]. Surveyed major pomegranate areas in India during 2005-09 and reported higher disease incidences in Maharashtra (49.2%), Karnataka (61.11%) and Andhra Pradesh (8.69%).

With respect to districts, the highest incidence of pomegranate wilt was recorded in Bagalkot (15.27%) district followed by Vijayapura district (6.23%), while least incidence of wilt was recorded in Chitradurga district (3.75%) during 2015-16. Further, five year above old orchards showed a higher disease compared to younger orchards during the recent study. It was also noticed that wherever shot hole borer and nematode association was noticed, the wilt incidence was higher, while wilt incidence, shot hole borer and the root knot infection was high in black soil compare to red soil. Similar kind of observations was noticed by [9] who reported that wilt incidence ranged from 22.3 to 45.2 per cent in different surveyed locations of six northern districts. Among the orchards, 4-5 year old orchards showed a higher disease than the plants aged three years or less and orchards showing higher wilt incidence also showed an association with the borer. [6] Reported that in Maharashtra wilt prevalence was more in the districts of Satara (91.66%), Pune (90.0%), Nashik (66.66%), Solapur (47.05%) and Ahmednagar (50.0%). In Karnataka, 61.11 per cent prevalence was recorded in Koppal, Bagalkot and Vijayapura districts whereas, in Anantapur district of Andhra Pradesh wilt were observed in 8.69 per cent of the orchards. Further, the higher incidence of pomegranate wilt disease in Bagalkot and Vijayapura districts may be due to the continuous cultivation of the crops since many years. These districts are traditional pomegranate growing belts where pomegranate is growing in large area as a sole crop resulting in more buildup of inoculum. It was noticed during the survey that, the farmers of these districts are not practicing any type of cropping pattern. Among the taluks, the highest mean incidence of wilt (19.93%) was recorded in Bagalkot taluk of Bagalkot district followed of Badami taluk (10.61%) of Bagalkot district and Vijayapura taluk of Vijayapura district (9.27%). The lowest incidence of pomegranate wilt (3.20%) was recorded in Indi taluk of Vijayapura district. Out of 88 orchards, three orchards recorded wilt in severe form (> 50.0% incidence), 12 orchards revealed moderate incidence (10-50%), while 73 orchards recorded mild (up to 10%) wilt incidence. Similar studies were conducted by [6] by in Karnataka, Andhra Pradesh and Maharashtra wherein wilt was prevalent in 47.57 per cent of orchards, of which only 5.82 per cent had severe wilt infections, 10.03 per cent moderate and 31.71 per cent mild wilt infections and the disease was prevalent on all important cultivars. These results are in conformity with the results of [7]. A survey of 44 locations in Maharashtra from 1995 to 1998 showed 7.5 per cent crop losses. In Karnataka, wilt incidence was reported from Bagalkot, Vijayapura, Bilagi, Kanamadi, Tikota, Sindagi, Indi, Talikoti and Tajpur locations [8].

The higher disease incidence in Bagalkot and Vijayapura in the present study may be due to the mono cropping of Bhagwa variety since many years. As there is no resistance variety available, farmers are forced to go for susceptible Bhagwa variety. The susceptible variety cultivated for a long time will build up the soil inoculum. [1] Screened four pomegranate cultivars/varieties against wilt disease of pomegranate under glass house condition. The maximum wilt disease incidence was recorded in the cultivar Bhagwa which was followed by Mridula, Arakta and G-137. Over all it was found that none of the varieties showed resistance to wilt disease. Secondly, farmers are using local planting material which is neither certified nor completely ensured that they are from disease free orchards. Thus, initial inoculum through planting material, accompanied by susceptible variety and prevailing congenial soil and climatic conditions help to aggravate the disease. Practicing improper management practices by farmers in the initial period of the crop also make it difficult to manage the wilt. As per the present recommendation, on observing first symptoms of wilt in the orchard farmers need to drench the roots of infected plants and healthy plants surrounding the infected plants with chemical/bio-agents. But this is not happening in the farmers fields either because the unawareness of the control measure or negligence of the farmers. Moreover, infected plants are not removed timely the from field. The dead trees need to be removed and fresh planting is to be done after treating the soil with formalin. This is not strictly practiced by the farmers. So the pathogens survive in the field and cause the disease in higher proportions. The prophylactic management practices were also not followed by farmers to manage the fungal wilt disease of pomegranate in almost all the locations surveyed. This is in agreement with [9] who reported that the pomegranate wilt was most severe in districts such as Bellary, Koppal, Gadag, Vijayapura and Raichur in Karnataka.

Soil sample analysis

Eighty eight soil samples were collected during the survey from different districts were analyzed for the parameters EC, pH and bulk density. The results are presented in Table 2.

Soil sample analysis for Electric conductivity (EC ms/m)

Electric conductivity of soil samples of Bagalkot district ranged from 0.13 to 1.68. In Ballari district soils EC ranged from 0.13 to 0.91, while in Chitradurga district it was 0.08 to 0.41. With respect to Koppal district it was in the range of 0.10 to 0.65. Vijayapura district recorded EC in the range of 0.13 to 0.86.

Soil sample analysis for pH

The pH of soil samples collected from Bagalkot district ranged from 6.98 to 8.95. In Ballari district soils pH ranged from 7.27 to 8.61, while in Chitradurga district it was 7.76 to 9.06. With respect to Koppal district it was in the range of 7.51 to 8.34. Vijayapura district recorded in the range of 7.53 to 8.88.

Soil sample analysis for Bulk Density (BD g/cc)

The bulk density of soil samples from Bagalkot district ranged from 0.41 to 1.28, while in Ballari district ranged from 1.06 to 1.28. In Chitradurga district it was in the range of 1.02 to 1.38. In Koppal district it ranged between 1.03 to 1.25. Vijayapura district recorded BD in the range of 0.91 to 1.20. A basic characteristic of soil fungi is their mycelial growth form and mycelial exploration through soil is influenced by

soil physical characteristics since hyphae must ramify through the complex heterogeneous network of pores. The effects of physical conditions on hyphal spread are difficult to ascertain because of the geometric complexity of the pore networks^[10]. Furthermore, soils are comprised of interdependent solid, liquid and gaseous phases, where altering one of the components could indirectly affect the other phases or associated processes. Many factors may modulate fungal growth in soils, such as nutrient availability, pH, aeration, and microbivory^[3].

Correlation coefficient of different soil parameter with per cent disease incidence of *C. fimbriata*

The correlation coefficient of per cent disease incidence with different soil parameters is presented in the Table 3. Electric conductivity showed the significant positive correlation with per cent disease incidence ($r = 0.30$). pH ($r = -0.04$) and bulk density ($r = -0.11$) showed non-significant values with per cent disease incidence.

The present study on correlation analysis between per cent disease incidence with different soil parameters had showed the significant positive correlation between electric conductivity with per cent disease incidence.^[5] Reported that increase in EC level increased the activity of the cell wall-degrading enzymes cellulase and glucanase of *Trichoderma polysporum* plus and *T. harzianum* in a closed soilless system. pH and bulk density had showed non-significant values with per cent disease incidence. The result obtained from *in vitro* study showed that *C. fimbriata* can grow at a wide range of soil pH 4 to 9^[4]. Who reported fungal hyphae were more often found in areas with a higher porosity, in particular at low soil bulk densities.

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