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Spatio-temporal diversity of dry root of pigeonpea caused by *Rhizoctonia bataticola* in major pigeonpea growing areas of Karnataka

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Abstract
Dry root rot is an emerging and one of the most destructive constraint for pigeonpea production. As the disease is more prevalent with hot climate at 30 to 35 °C temperature (Taya *et al*., 1988). Low soil moisture conditions in Northern eastern Karnataka. To, calibrate the incidence and spread of the disease, a roving survey was taken up during the cropping season of 2017, 2018 & 2019 at prefixed plots. Four major pigeonpea growing districts such as Raichur, Kalaburgi, Yadgir and Bidar were chosen to evaluate the status of incidence and severity. Geo tagging *viz*., longitude latitude was taken up from each taluk three to five villages were selected randomly for survey. Results indicated that, During 2017-18 & 2018-19 maximum incidence of dry root rot was observed in Sultanpura village of Raichur district with the incidence of 17.2% & 28% respectively. Followed by Shirasagi village of Kalaburagi district with the record of 16.5% & 27.3%. Least dry root rot incidence of was observed in Mirjapur & Hippagar villages of Bidar district with the incidence of 8.6% & 11.00% respectively. During the *Kharif* 2019-20 recorded highest incidence of 17.5% was recorded in Hirapur village of Kalaburagi district followed by raichur district with the incidence of 13.00% in Yermarus village and the least incidence of 5.00% was observed in Tadola village of Basavakalyan taluk. From the survey, it is clear that Pigeonpea crop in Raichur district was most affected due to dry root rot incidence.

Keywords: Latitude, longitude, dry root rot, survey, pigeonpea

Introduction
The term pigeonpea was coined in Barbados, where its seeds were considered as a very important feed for pigeon. The word Cajanus comes from Malay word 'Katschang' or 'Katjang', which implies pod or bean. It belongs to the Leguminoseae family and may be a short-lived perennial shrub, that's traditionally cultivated as an annual crop in developing countries. it's fast growing, hardy, widely adaptable and drought resistant, often cross pollinated (20 - 70%) which is alleged to be awfully old and one in every of the important leguminous crops of tropics and subtropics. it's a diploid legume crop species (2n = 2x = 22), belongs to the tribe Phaseoleae. it's the potential to revive soil fertility by fixing atmospheric nitrogen and has the flexibility to solubilize fixed phosphorus (Ae *et al*., 1990) [1]. it's widely used as a pulse, green vegetable, fodder and for a range of other purposes. additionally, it can be cut for forage and improves poor soil through its deep strong rooting systems, leaf drop at maturity and addition of nitrogen by symbiotic activities during crop growth. It has multiple uses such as tender green seeds used as vegetables, stem and roots as fuel wood, besides its main use as dhal. The seed protein content of Pigeonpea (21%) compares well with that of other important grain legumes. Considering importance of pulses in human nutrition, government of India is giving much emphasis on increasing production of pulses in the country by making 2016 as International year of pulses.

The disease is widely spread over India, Myanmar, Nepal, Jamaica, Sri Lanka, Trinidad and Tobago. It is caused by *Rhizoctonia bataticola* (Taub.) [Pycnidial stage is *Macrophomina phaseolina* (Tassi) Goid] which is soil and seed borne necrotrophic fungal pathogen, that has a global distribution. The pathogen can infect more than 284 plant species throughout the world including monocot and dicots (Farr *et al*., 1995) [3]. The fungus exists in two forms, one saprophytic (*R. bataticola*), producing microsclerotia and another is pathogenic (*M. phaseolina*), which produces pycnidia. There is need to intensify the research on soil borne diseases of pigeonpea with special emphasis on dry root rot.

Hence the present investigation was undertaken to survey for dry root rot wilt of pigeonpea during three consecutive years 2017, 2018 and 2019.

Materials and Methods

A roving survey was conducted in major Pigeonpea growing areas North Eastern Karnataka *viz.*, Raichur, Kalaburgi, Bidar and Yadgir districts for Fusarium wilt & other soil borne diseases of during 2017- 18, 2018-19 and 2019-20. Survey was conducted at flowering to pod filling stage of the crop. In each taluk, five villages were selected and in each village observations were drawn for the incidence of Fusarium wilt.

The following formula was used to calculate the disease incidence

$$\text{Disease incidence} = \frac{\text{Number of plants wilted}}{\text{Total number of plants observed}} \times 100$$

Disease rating scale for dry root rot is given by Ajithkumar *et al*. (2018) categorized as follows

Disease incidence (%)	Disease reaction
0 – 10	Resistant
10.1 – 20	Moderately resistant
20.1 – 50	Moderately susceptible
50.1 – 80	Susceptible
80.1 – 100	Highly susceptible

Collection and isolation of diseased specimen

The field survey was carried out during October - November, for three consecutive years. The affected plant samples were collected from different farmer's fields. After collection, plant samples were brought to the laboratory and washed thoroughly under running tap water. The basal stalk portion and roots of affected plants were separated, & dried under shade for 3-4 days and preserved for further use.

The Pathogen was isolated by adopting a standard tissue isolation method. Pigeonpea plants showing typical dry root rot symptoms collected from different locations were used for isolation. The plant samples were cut into small bits, surface sterilized by dipping in 1% sodium hypochlorite for one minute, then rinsed with 3 changes of sterile distilled water, blot dried and then transferred aseptically on to Petriplates containing sterilized PDA medium at equidistance @ 5 bits/Petriplate. The inoculated Petriplates were incubated at 25 + 2^{o}C in an incubator.

Results and Discussion

Epidemiology

A serious problem in late-sown or summer crops and in perennial or ratooned pigeonpea. The disease also affects short-duration pigeonpeas sown in the rainy season. Hot (30 °C and above) and dry weather encourage disease development, that is more prevalent on Vertisols than on Alfisols. Rain after a prolonged dry spell predisposes plants to the disease. Crops are more susceptible in the reproductive stage than in the vegetative stage.

Symptoms

Infected plants suddenly and prematurely dry up. When such plants are uprooted their roots are rotten and shredded (Plate. 1). The finer roots are mainly affected and have dark, black end streaks underneath their bark with evident dark sclerotial bodies (Plate. 2 & 3). Such roots are brittle and break when touched. Under hot, humid conditions root rotting extends to the base of the stem. Early symptoms on stems and branches are spindle-shaped lesions with light gray centers and brown margins with scattered pycnidial bodies. The lesions coalesce and cause the branches or whole plants to dry up and die.

Isolation and pathogenicity

The isolated pathogen was collected from infected plants from different places of major pigeon pea growing areas of Karnataka. All the ten isolates varied both cultural and morphological characters such as mycelium and sclerotial formation. The mycelium was pale white in color in the initial stages of the growth, later turned to dark brown to black as and when sclerotia formation started.

The hyphal constriction at the point of branching i.e., right angle branching (Plate 4). Formation of fruiting body (sporodochium) was observed. Conidial formation on conidiophores was observed. The Aerial mycelium aggregated to form numerous dark brown to black colored sclerotia noticed on the culture. Also the formation of chlamydospre was observed. Mycelial branching was right and acute angled and moniloid cells (specialized hyphae composed of compact cells) were also observed. The monilioid cells fuse together to produce hard structures called sclerotia.

Prevalence, occurrence and distribution of dry root rot in pigeonpea

Survey report of dry root rot during the year 2017-18 revealed that, maximum incidence (Table 1) of 17.2 per cent was observed in Sultanpura (Raichur) followed by 16.5 per cent in Shirasagi and Padavasahalli (15.6%) villages of Kalaburagi district. Dry root rot incidence was not observed in Kalmal, Nandihal and Jakkaladinni villages of Raichur district, Madbol and Telkarni villages of Kalaburagi district, Nalvari, Yaragol, Aralahalli, Madrike and Lakshmipur villages of Yadgir district and Kanakatta village of Bidar district.

Taluk wise mean incidence during 2017-18 revealed that (Table 1, Fig 1), the maximum dry root rot incidence was noticed in Kalaburagi (12.5%) taluk. Moderate incidence was observed in Raichur (7.70%), Jewargi (5.36%) and Aland taluks (4.7%). Minimum incidence of 1.0 per cent was observed in Manvi taluk.

Unlike *Fusarium* wilt, dry root rot incidence was not found much prevalent in all the four districts (Table 1) surveyed during 2017-18. However, district wise disease incidence ranged between 2.61 to 5.50 per cent with little bit maximum incidence in Kalaburagi district.

Dry root rot scenario during 2018-19 revealed that (Table 2, Fig 2), maximum incidence (28%) was observed in Sultanpura village of Raichur district, followed by Shirasagi (27.3%), and Jewargi (25.6%) villages of Kalaburagi taluk. The crop in the villages of Muranapura, Mathahalli and Siravara villages of Raichur district, Margolla and Aurad villages of Kalaburagi district and Shantalabad village of Bidar district was completely found free from dry root rot incidence.

When different taluks of all the district were compared during 2018-19, Kalaburagi was found first in recording the maximum dry root rot of 16 per cent followed by Lingasugur with 13.6 per cent incidence (Table 2).

Compared to 2017-18, district wise mean severity of dry root rot during 2018-19 was quite more with maximum incidence of 11.4 per cent in Kalaburagi district, then followed by

Raichur (10.6%). Minimum mean incidence of 3.66 per cent was observed in Bidar district (Table 2).

Dry root rot incidence during 2019-20 indicated the maximum incidence (Table 3) in Hirapur village (17.5%) of Kalaburagi taluk followed by Yermarus of Raichur district with maximum incidence of 13 per cent. Moderate dry root rot incidence of 11 and 11.5 per cent was noticed in Yergera and Deodurga villages of Raichur district and Padavasahalli of Kalaburagi district. No disease incidence was observed in Sajjalaguda village of Raichur district, Chigarahalli, Ijeri and Neelhalli villages of Kalaburagi district, Shettihalli, Birnoor, Ayyala, and Madrike of Yadgir district and Shivapura and Shanltabad of Bidar district.

Among different taluks surveyed during 2019-20 (Table 3), Kalaburagi recorded the maximum mean incidence of 11.0 per cent. Moderate incidence in the range of 6.30 to 7.30 per cent was noticed in Manvi (6.30%), Deodurga (7.1%) and Aland (7.3%) taluks. Minimum incidence (1.04%) was observed in Yadgir taluk.

Dry root rot scenario among the different districts revealed the maximum incidence of 5.6 per cent observed in both Kalaburagi and Raichur district. However, district wise mean incidence during 2019-20 was found quite similar to that of 2017-18 as the disease incidence ranged between 1.7 to 5.6 per cent (Table 3).

Average dry root rot incidence in different taluks over the years revealed the maximum incidence of 13.2 per cent as recorded in Kalaburagi taluk. The minimum incidence (1.73%) in Humnabad taluk.

Mean dry root rot incidence in different districts over the years exhibited the maximum incidence of 7.50 per cent in Kalaburagi district followed by Raichur district (6.70%). Whereas, the minimum incidence of 2.66 per cent was observed in Bidar district.

The results of the present survey were found similar with the studies conducted by Maruti *et al*., (2017) in Raichur, Kalaburgi, Yadgir and Bidar districts. They conducted the survey during 2015 and reported the maximum dry root rot incidence in Kalaburgi district (24.72%) and then in Raichur (17.78%) and minimum in Yadgir (9.44%) district.

Similarly Manjunatha *et al*. (2011) [6] observed the maximum dry root rot incidence in Kalaburagi (9.8%) then followed by Raichur (7.6%) and minimum incidence in Bidar (6.18%) district.

Khan *et al*., (2012) [5] made an intensive survey to assess the occurrence and incidence of dry root rot in Jammu and Kashmir. The disease intensity was found high in the month of February and March during late flowering and podding stage. The maximum incidence was recorded in Shangus (40%) and minimum Naina (4.11%) villages.

Studies on prevalence of dry root rot was conducted by Gurha and Trivedi (2008) [4] in different districts of Karnataka and they found that the disease was more prevalent in Kalaburagi and Raichur district with 60- 70 per cent incidence. On the contrary, Shivamogga and Bangalore districts recorded maximum of 10 per cent disease incidence. These observations are in agreement with Manjunath *et al*., (2011) [6] where they reported that chickpea plants to moisture stress conditions evidenced during rabi season, which ultimately led to more production of sclerotia of Rhizoctonia sp. on chickpea plants roots (Pande *et al*., 2004).

A. B.

C. D.

Plate 1: A & B. Dry root rot affected farmer's field C. Symptoms of dry root rot of pigeonpea D. white mycelial growth on roots

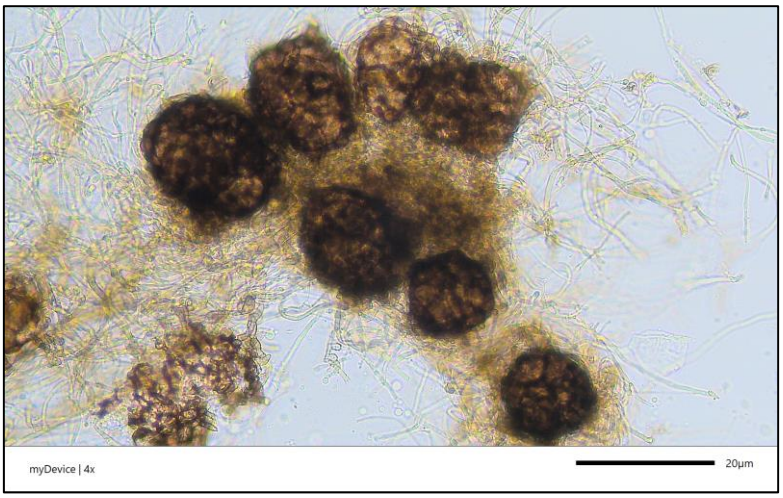

Plate 2: Mass of sclerotial bodies

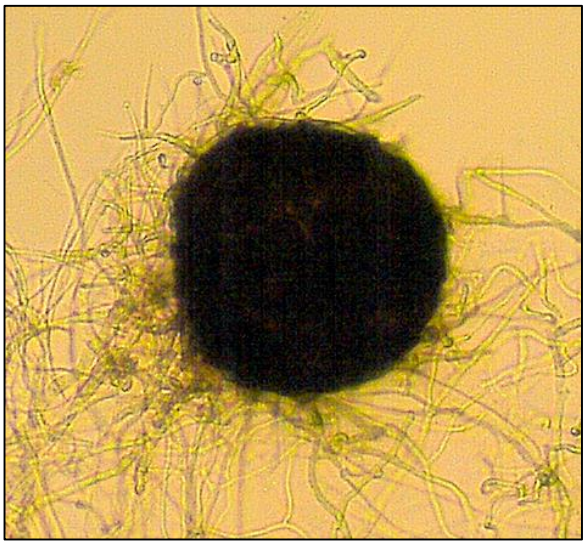

Plate 3: Formation of sclerotial body

Plate 4: Right angled hyphal formation

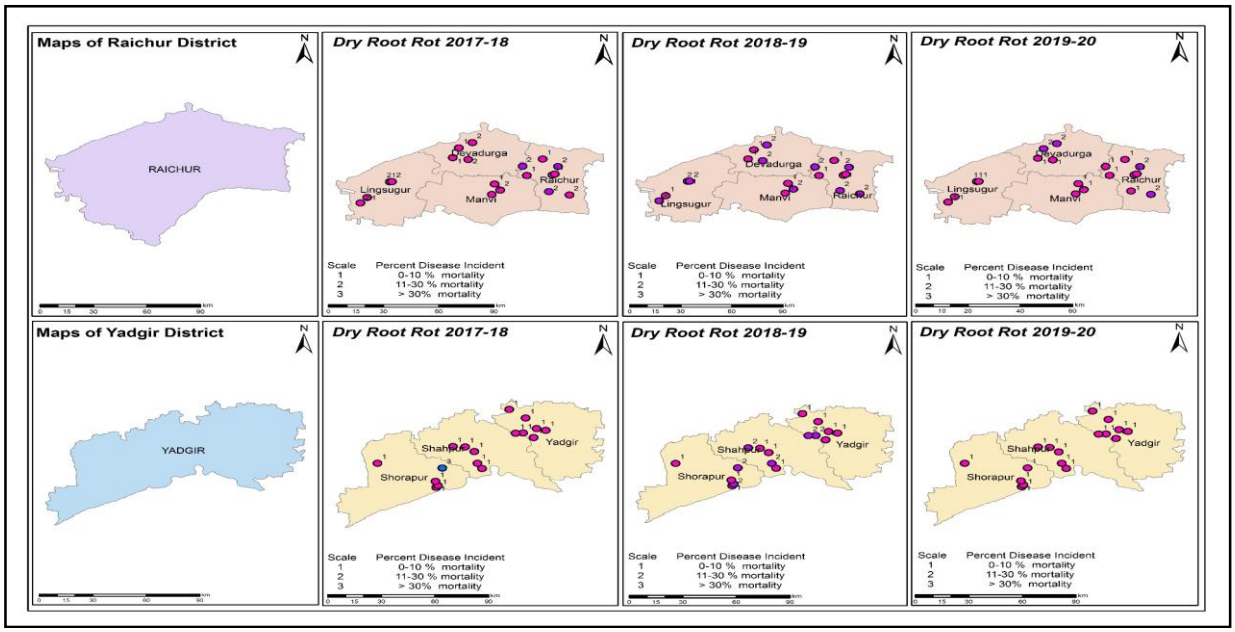

Fig 1: Cartographical representation of dry root rot blight of pigeonpea in Raichur and Yadgir districts

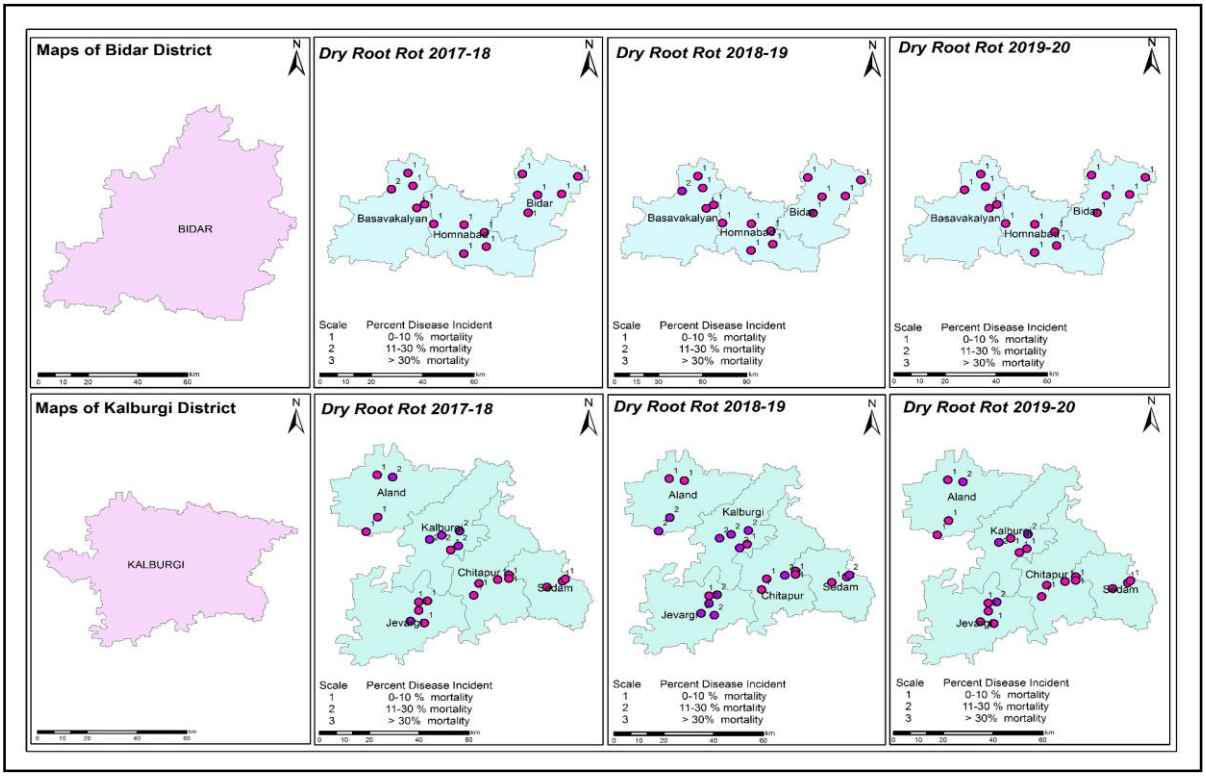

Fig 2: Cartographical representation of dry root rot blight of pigeonpea in Bidar and Kalaburgi districts

Table 1: Status of dry root rot incidence in major pigeonpea growing areas of Karnataka

Sl. No.	Districts	Taluks	Villages	No. of fields visited (Av)	Soil type	Percent Disease incidence		
						2017-18	2018-19	2019-20
1	Raichur	Raichur	Yermarus	5	Black soil	12.50	20.0	13.0
			Yergera	4	Black soil	9.70	19.5	11.0
			Sultanpura	5	Black soil	17.2	28.0	1.00
			Timmapur	5	Black soil	13.2	17.2	3.70
			UAS campus	4	Black soil	7.80	5.20	8.00
			Hunsalahada	3	Black soil	0.50	2.50	1.00
			Muranapura	3	Black soil	0.30	0.00	3.00
			Kalmal	3	Black soil	0.00	2.30	2.00
		Mean				7.70	11.8	5.30
		Lingasugur	Nandihal	4	Black soil	0.00	9.50	7.00

			Hirelekkihal	3	Black soil	7.20	18.0	2.80
			Chikkalakkihal	5	Black soil	5.00	7.20	3.00
			Sajjalaguda	5	Black soil	1.00	13.5	0.00
			Amadihal	5	Black soil	2.70	20.0	4.50
		Mean				3.18	13.6	3.46
		Deodurga	Deodurga	5	Black soil	8.00	22.5	11.0
			Mathahalli	3	Black soil	0.50	0.00	1.20
			Chikkabidu	4	Black soil	0.30	15.7	3.70
			Anjigur	5	Black soil	5.50	5.00	12.5
		Mean				3.57	10.8	7.10
		Manvi	Shakapur	4	Black soil	2.00	5.20	4.00
			Siravara	3	Black soil	1.00	0.00	7.00
			Jakkaladinni	5	Black soil	0.00	12.6	8.00
		Mean				1.00	5.90	6.30
	Mean					3.90	10.6	5.60
2	Kalaburgi	Chittapur	Revur	3	Black soil	3.80	3.20	5.00
			Margolla	3	Black soil	0.50	0.00	1.00
			Evani	4	Red soil	0.30	11.5	2.00
			Madbol	4	Black soil	0.00	7.50	1.50
			Sannur	5	Black soil	8.60	8.70	2.00
		Mean				2.64	6.18	2.30
		Kalaburgi	Shahbad	4	Black soil	13.2	3.20	7.00
			Nandur	5	Black soil	7.80	11.0	5.00
			ARS, Kalaburgi	5	Black soil	12.0	15.6	7.50
			Hirapur	5	Red soil	13.2	23.2	17.5
			Shirasigi	5	Black soil	16.5	27.3	18.0
		Mean				12.5	16.0	11.0
		Jewargi	Jewargi	5	Black soil	7.80	25.6	11.5
			Andola	3	Black soil	1.00	0.00	2.00
			Hargadda	5	Black soil	3.20	13.7	4.00
			Chigarahalli	4	Black soil	1.00	17.5	0.00
			Ijeri	5	Black soil	13.8	15.7	0.00
		Mean				5.36	14.5	3.50
		Aland	Padavasahalli	5	Red soil	15.6	5.20	11.5
			Honnahalli	3	Red soil	0.80	3.70	2.00
			Telkarni	4	Black soil	0.00	14.0	7.00
			Kadagandhi	5	Black soil	2.20	20.6	8.70
		Mean				4.70	10.9	7.30
		Sedam	Kodla	3	Black soil	1.00	10.0	5.00
			Adaki	4	Black soil	1.70	12.0	6.00
			Neelhalli	3	Black soil	3.70	5.70	0.00
		Mean				2.10	9.20	3.70
		Mean				5.50	11.4	5.60
3	Yadgir	Yadgir	Shettihalli	4	Black soil	6.00	6.80	0.00
			Nalvari	3	Black soil	0.00	5.60	1.30
			Pursapur	5	Black soil	7.20	9.20	2.50
			Birnoor	5	Black soil	5.80	10.7	0.00
			Ayyala	5	Black soil	1.20	12.0	0.00
			Yaragol	4	Black soil	0.00	9.70	1.50
			Alipur	3	Black soil	0.50	5.00	2.00
		Mean				2.96	8.43	1.04
		Shahapur	Aralahalli	3	Black soil	0.00	4.70	1.30
			Hothpet	5	Black soil	5.70	15.9	7.60
			Vibuthihalli	5	Black soil	3.70	13.7	5.00
			Beemarayanagudi	3	Black soil	0.30	1.00	1.50
			Madrike	3	Black soil	0.00	2.00	0.00
		Mean				1.94	7.46	3.08
		Surpur	Krishnapur	3	Red soil	0.40	0.30	0.50
			Titga	3	Black soil	0.60	4.50	2.00
			Satyapet	4	Black soil	9.00	13.2	0.30
			Hasanapuracamp	5	Black soil	8.20	14.5	3.30
			Lakshmipur	3	Red soil	0.00	0.90	1.00

		Mean				3.64	6.68	1.42
		Mean				2.85	7.52	1.85
4	Bidar	Bidar	Honnadi	3	Red soil	0.50	3.20	1.50
			Mirjapur	4	Red soil	8.60	2.10	2.00
			Janawada	3	Black soil	2.00	1.00	1.50
			Bynaha	3	Black soil	0.30	0.30	1.00
			Kapalapur	4	Black soil	0.50	4.00	4.00
		Mean				2.38	2.12	2.00
		Basavakalyan	Manavalli	4	Red soil	6.50	7.00	0.40
			Hippagara	5	Red soil	7.00	11.0	1.20
			Tadola	3	Red soil	1.00	2.00	5.00
			Bagduri	5	Red soil	5.20	6.50	0.20
			Shivapura	3	Black soil	3.20	5.30	0.00
		Mean				4.58	6.36	1.36
		Humnabad	Hankuni	3	Red soil	1.20	3.20	0.60
			Kanakatta	3	Red soil	0.00	1.00	3.00
			Hudagi	4	Black soil	0.20	2.70	4.00
			Nandagao	3	Black soil	2.00	5.60	1.40
			Shantalabad	3	Black soil	1.00	0.00	0.00
		Mean				0.88	2.50	1.80
	Mean					2.61	3.66	1.72

Table 2: Taluk wise mean incidence of dry root in major pigeonpea growing areas of Karnataka

Sl. No.	District	Taluk	Percent disease incidence			Average incidence
			2017-18	2018-19	2019-20	
1	Raichur	Raichur	7.70	11.8	5.30	8.27
		Lingasugur	3.10	13.6	3.46	6.76
		Deodurga	3.50	10.8	7.10	7.16
		Manvi	1.00	5.90	6.30	4.40
2	Kalaburagi	Chittapur	2.60	6.18	2.30	3.71
		Kalaburagi	12.5	16.0	11.0	13.2
		Jewargi	5.36	14.5	3.50	7.79
		Aland	4.70	10.9	7.30	7.63
		Sedam	2.10	9.20	3.70	5.00
3	Yadgir	Yadgir	2.96	8.43	1.04	4.14
		Shahapur	1.94	7.46	3.08	4.16
		Surpur	3.64	6.68	1.42	3.91
4	Bidar	Bidar	2.38	2.12	2.00	2.17
		Basavakalyan	4.58	6.36	1.36	4.10
		Humnabad	0.88	2.50	1.80	1.73

Table 3: District wise mean incidence of dry root rot in major pigeonpea growing areas of Karnataka

Sl. No.	District	Percent disease incidence			Average incidence
		2017-18	2018-19	2019-20	
1	Raichur	3.90	10.6	5.60	6.70
2	Kalaburagi	5.50	11.4	5.60	7.50
3	Yadgir	2.85	7.52	1.85	4.07
4	Bidar	2.61	3.66	1.72	2.66

Conclusion

The current study conducted across the locations and seasons revealed the maximum dry root rot incidence was recorded in Raichur district. Whereas Bidar district has recorded the minimum wilt incidence.

It is mainly enhanced by moisture stress and prolonged dry spell at maturity stage. Climate change is the major impact in spreading of dry root rot. Prolonged dry spells with less rainfall and drought conditions are convenient for the wide spread of pathogen in mean time. Also there are no resistant varieties against the dry root rot. The current study provides the data on the geotagging, prevalence and distribution of dry root rot incidence in major pigeonpea growing areas of Karnataka and to find out the hot spots of *R. bataticola* in different places of North eastern Karnataka. The prolonged dry spells due to the change in the weather

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