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SPATIAL DISTRIBUTION OF PIGEONPEA DISEASES AND THEIR INCIDENCES ACROSS MAJOR PIGEONPEA GROWING DISTRICTS OF NORTH KARNATAKA, INDIA

Mallikarjun Kenganal[1]*, Radhika Biradar[1], S. Muniswamy[1] and Aditya Pratap[2]

[1]All India Coordinated Research Project on Kharif Pulses, Pigeonpea Zonal Agricultural Research Station, Kalaburagi - 585 101, Karnataka, India.

[2]AICRP on Kharif Pulses, ICAR-IIPR, Kanpur, U.P., India.

*Corresponding author E-mail : mallikarjun_nss@rediffmail.com

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ABSTRACT

Pigeonpea, also known as *Cajanus cajan* L. Millsp., is an important pulse crop in Karnataka. It plays a big role in providing nutrition, improving soil health, and boosting the income of farmers, especially in the semi-arid areas. However, its production is facing challenges due to various diseases that are being caused by changes in the climate, growing the same crop repeatedly, and poor farming practices. In 2023 and 2024, during the kharif season, a survey was done in the districts of Kalaburagi, Yadgir, Vijayapur and Raichur. The survey looked at how common seven main diseases were and where they were spreading. These diseases include Fusarium wilt, Sterility Mosaic Disease (SMD), Phytophthora Stem Blight (PSB), Macrophomina Stem Blight (MSB), Alternaria Leaf Spot (ALS), Cercospora Leaf Spot (CLS) and Dry Root Rot (DRR). Fusarium wilt continued to be a big problem in traditional hotspots like Nimbarga and Ravoor. SMD stayed at a moderate level in areas where it's commonly found. In 2024, there was a noticeable increase in the number of cases of PSB and MSB, especially in places that are often waterlogged or suffer from drought. New leaf diseases like ALS and CLS were found at worrying levels in several areas for the first time. These diseases were more common because of long monsoon rains and dense plant growth. Dry Root Rot became the biggest threat in 2024, with more than 35-40% of crops affected in places like Aland, Kadaganchi and Tadkal. This was because of drought, bad soil quality, and less organic matter in the soil. Some widely grown varieties, such as TS-3R, GRG-811 and GRG 152 were found to be more easily affected by PSB, MSB and DRR. This shows that there's a need for new plant types that are better at resisting these diseases in specific areas. The study also found that the areas where these diseases occur have been changing over the years, showing how weather patterns are affecting them. The research emphasizes the importance of using a mix of strategies to control these diseases, including using disease-resistant varieties, applying fungicides on time, rotating crops, improving drainage, restoring soil health and keeping a close watch on disease outbreaks to keep pigeonpea production going in Karnataka.

Key words : Pigeonpea, Climate change, Survey, Diseases, Karnataka.

Introduction

Pigeonpea, also called tur or arhar in India, is a very important legume crop grown in the country. It is a key source of protein for many people, especially those who follow a vegetarian diet and helps to fight against protein and energy deficiencies. This crop is rich in protein, carbs, minerals, and essential amino acids. It is a major part of traditional Indian meals and plays a big role in keeping the country's food supply and nutrition safe (ICAR-IIPR, 2022). Besides being good for eating, pigeonpea also helps the environment. It is a deep-rooted plant that can fix nitrogen in the soil, which makes the soil more fertile. This is especially useful for farming in dry and poor soils. It can grow even in places with little rain, making it ideal for farming in dry areas, like parts of India's semi-arid regions. It also supports different types of farming, helps restore damaged land, and aids in soil protection (ICRISAT, 2021).

India is the biggest grower of pigeonpea worldwide, with about 82% of the global area and production. In the 2021-22 season, pigeonpea was grown on around 5.05 million hectares, producing 4.34 million tonnes with an average yield of 859 kg per hectare (ICAR-IIPR, 2022). The main states growing pigeonpea include Karnataka, Uttar Pradesh, Madhya Pradesh, Maharashtra, Gujarat, and Andhra Pradesh. Uttar Pradesh was responsible for nearly 34.9% of the national production. Karnataka is the top pigeonpea-producing state in India, making around 1.126 million tonnes, which is about 29% of the country's total output. In the 2023-24 season, Karnataka once again led in pigeonpea production, with a big jump in the area under cultivation. The total area went up to about 15.29 lakh hectares, which is a 69% increase from 9.05 lakh hectares in 2022-23. This accounts for 33% of the country's total area and production. Because of its role in food security, income, and soil health, pigeonpea is a key crop in Karnataka's farming systems, especially as the climate becomes more uncertain. Despite the increase in area being farmed, the average yield in Karnataka during 2022-23 was about 701 kg per hectare, which is lower than the national average. This is because most of the pigeonpea grown in Karnataka is in rainfed areas, making it more vulnerable to climate changes and unpredictable monsoons. The main reason for the lower yield is an increase in diseases over the past few years.

In 2022 and 2024, farmers in Karnataka, especially in areas like Kalaburagi, Bidar, Raichur, Yadgir and Vijayapura, had big problems with diseases that made pigeonpea plants wilt. These diseases were caused by different harmful organisms like *Fusarium udum*, *Rhizoctonia bataticola*, *Phytophthora drechsleri* and *Alternaria blight*. In 2022, heavy rains made things worse, and a large area of over 1.98 lakh hectares in Kalaburagi was hit badly. Other regions also saw serious issues with both wet and dry root rot. In 2024, again, more than 1.2 lakh hectares in Kalaburagi was lost because of these diseases. *Alternaria blight* also caused a lot of damage in some places. By the 2023–24 season, the problem continued in many areas. These situations show how important it is to track the spread and effects of different pigeonpea diseases during farming to know where they are common, how bad they are, and how well different pigeonpea varieties fight these diseases. This information can help make better plans to manage the diseases in different parts of North Karnataka where pigeonpea is grown during 2023 and 2024.

Materials and Methods

A systematic roving survey was conducted of major pigeonpea diseases during 2023 and 2024 *kharif* seasons across the major pigeonpea-growing districts of North Karnataka, namely Kalaburagi, Raichur, Vijayapur and Yadgir. These districts collectively represent the core pigeonpea production belt of the state, characterized by varied agro-climatic conditions and cropping patterns. The survey was carried out coinciding with key crop growth stages: vegetative, flowering and pod development stages to capture the temporal dynamics of disease occurrence and distribution.

During the visits, pigeonpea fields under farmer's management were randomly selected, ensuring a representative coverage of each district's pigeonpea-growing area. At each selected field, the GPS coordinates were recorded using a handheld GPS device (Garmin eTrex 32x) with a maximum positional accuracy of ±5 meters. This enabled precise georeferencing of disease incidence data for subsequent spatial analysis.In each field, systematic disease assessment was carried out by walking in a zig-zag pattern across the field and recording disease symptoms on 50 randomly selected pigeonpea plants per field. Observations were made for the incidence and severity of the diseases, including Fusarium wilt, Phytophthora blight, Sterility Mosaic Disease (SMD), Dry Root Rot (DRR), Macrophomina Stem Blight (MSB), Cercospora Leaf Spot (CLS) and Alternaria Leaf Spot (ALS) diseases.

Per cent Disease Incidence (%) was calculated as the number of infected plants out of the total number of plants observed per field. Disease severity for each foliar disease was assessed using standard disease scoring scales recommended by AICRP on Pigeonpeabased on symptom intensity and plant damage. Detailed notes on symptomatology, disease progression, crop growth stage, variety grown, and crop management practices were also recorded for each field during the visits.

The field data collected from all the surveyed locations were systematically compiled and entered into Microsoft Excel 365 for initial tabulation and descriptive analysis. Disease incidence and severity data were then linked to their respective geospatial coordinates. To visualize the spatial distribution and intensity of major diseases, the compiled data were imported into free and Open-Source Geographic Information System software. Spatial maps were generated with indicator for each major disease showing their geographical spread and hotspots of incidence across North Karnataka. This spatial analysis enabled the identification of disease hotspots, emerging disease trends, and temporal shifts in disease prevalence over the two seasons.

Results and Discussion

A systematic roving survey was conducted during the kharif seasons of 2023 and 2024 to record the incidence and distribution of major pigeonpea diseases in North Karnataka. Among the different diseases, Fusarium wilt (FW), Sterility Mosaic Disease (SMD), and Phytophthora Stem Blight (PSB) remained prominent in affecting crop health and yield. The survey outcomes reflected significant spatio-temporal variability (Figs. 1 and 2) in disease incidence, influenced by cropping systems, varietal susceptibility, rainfall patterns and agronomic practices. Major pigeonpea growing visited is mapped representing geographical area surveyed from the districts growing pigeonpea (Fig. 3).

Fusarium wilt: Fusarium wilt remained one of the most widely prevalent and destructive soil-borne diseases of pigeonpea during both years of the survey. In 2023, wilt incidence varied from 1.08 to 21.02 per cent, with higher incidences recorded in fields at Nimbarga (21.02%), Bhoosnur (17.95%) and Ravoor (15.32%). Several other locations such as Ankalaga, Mahagaon and Neelahalli also reported disease incidence levels exceeding 12 per cent.

In 2024, wilt incidence showed a relatively narrower

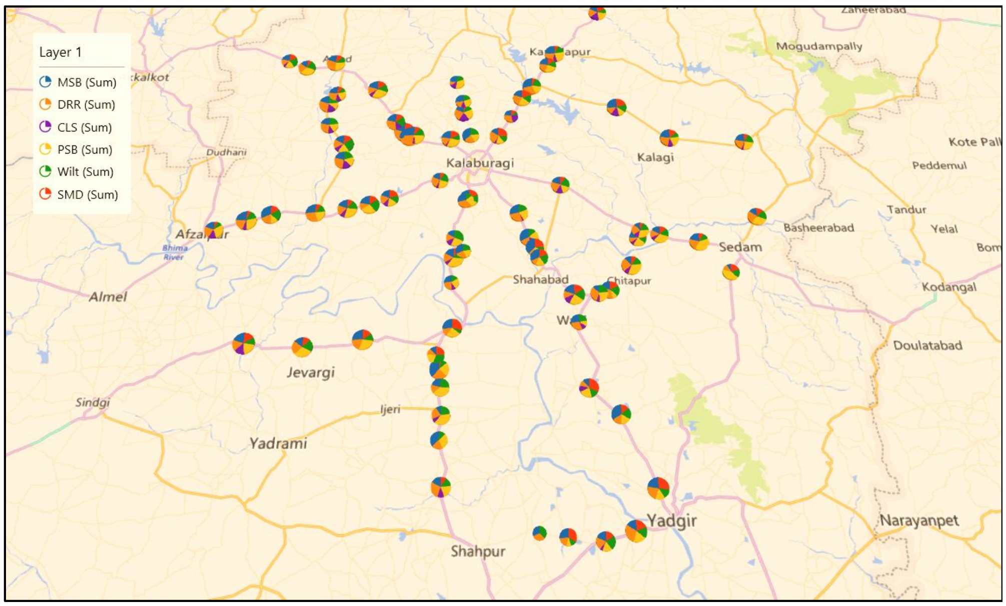

Fig. 1 : Scattered GPS enabled map of pigeonpea diseases surveyed during 2023 in Kalaburagi and Yadgir districts.

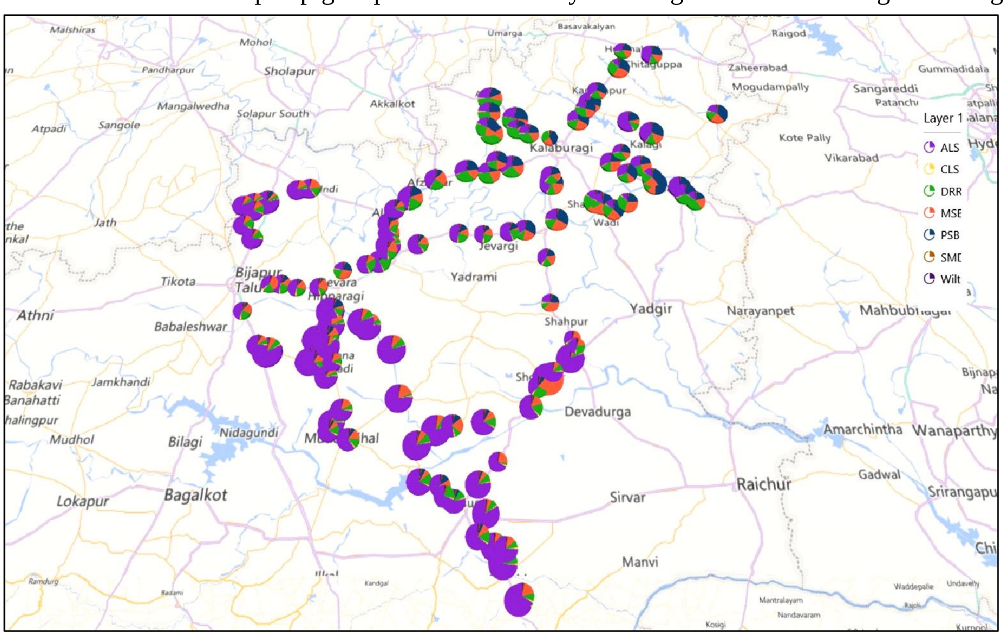

Fig. 2 : Scattered GPS enabled map of pigeonpea diseases surveyed during 2024 in Kalaburagi, Vijayapur, Raichur and Yadgir districts.

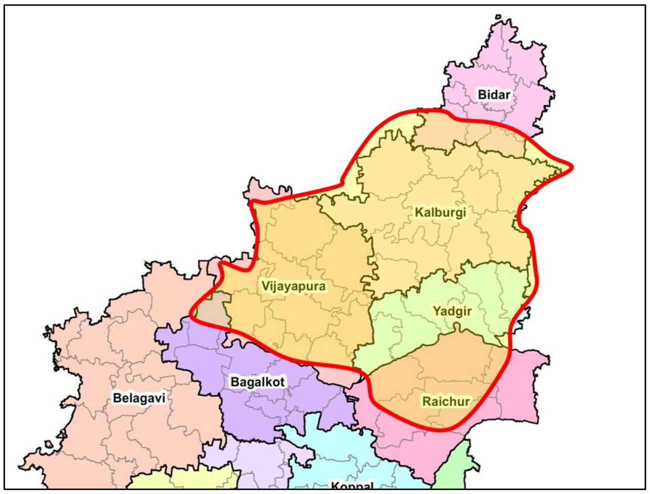

Fig. 3 : North Karnataka districts surveyed for different diseases of pigeonpea during 2023 and 2024.

Fusarium wilt remains a key production constraint in the region due to the long survival ability of the pathogen in soil and plant debris, often lasting several years without host presence. Its incidence and distribution patterns were influenced by soil type, water stagnation, and cropping history. As suggested by Sharma *et al*. (2020), adoption of resistant varieties and proper soil moisture management significantly reduces wilt intensity.

Recent multi-location pigeonpea disease surveys from Maharashtra and Telangana also reported similar trends, with wilt persisting at moderate to high levels in continuous cropping areas (Rameshwar *et al*., 2022). Integrated management practices including seed treatment with Trichoderma and crop rotation with cereals could reduce disease pressure in endemic areas.

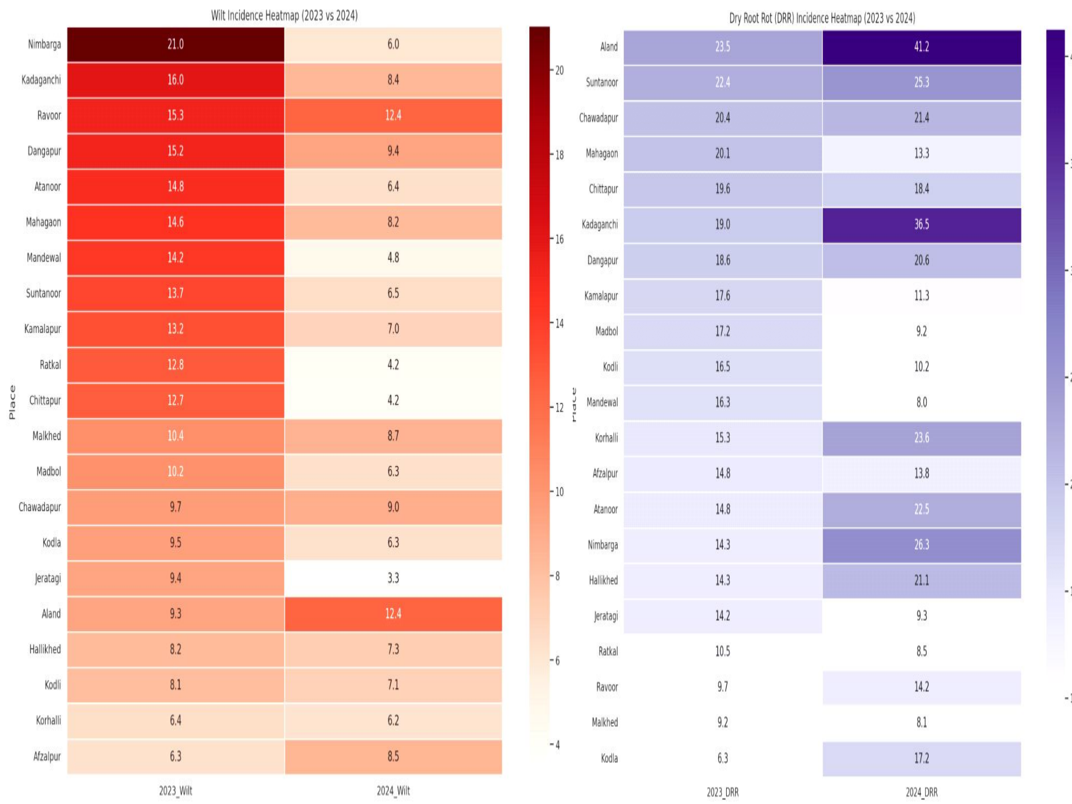

Fig. 4 : Heat map showing Wilt & DRR incidences on same places during 2023 & 2024.

range of 0.25to 12.58 per cent, with prominent fields including Betgera K (12.58%), Aland (12.36%) and Mahagaon (8.25%). Although, the overall incidence of Fusarium wilt showed a slight decline in most areas during 2024, isolated pockets with persistently high incidences indicated the survival and build-up of soil inoculum and repeated cropping of same varieties and crop (Fig. 4).

This pattern corroborates with earlier findings that continuous pigeonpea mono-cropping in Vertisols combined with terminal drought stress aggravates wilt severity (Pande *et al*., 2013 and Reddy *et al*., 2022).

Although, the currently cultivated varieties GRG 811 and GRG 152 are resistant to wilt, other variety TS-3R released more than 13 years ago has become more prone to Fusarium wilt and was found infested in most of the plots sown. Due to its short duration and drought tolerance many farmers tend to grow this in rain-fed areas, but were found struggling to manage wilt. The overall observations highlighted the need for introduction of wilt resistant, short duration, drought tolerant and high yielding pigeonpea varieties in replacement of TS-3R or an improvement over this cultivar for the surveyed areas.

Table 1 : Spatial distribution of different disease of pigeonpea in North Karnataka during 2023.

S. no.	Districts	Name of the place	Per cent disease incidence (%) / Percent Disease Index (PDI)						
			Wilt	SMD	PSB	DRR	MSB	CLS	ALS
			% incidence					PDI	
1	Kalaburagi	Sirnur	6.92	0	12.36	16.36	14.58	0	0
2		Farhatabad	18.23	0	14.25	9.36	9.25	6.23	15.25
3		Saradagi	14.26	5.62	23.67	12.46	12.25	4.19	10.25
4		Tilgul	10.3	0	8.36	10.58	14.14	0	0
5		Naddisinnur	6.25	0	10.25	9.65	10.36	3.35	0
6		Raddewadagi	4.14	18.54	14.98	8.12	17.04	0	5.21
7		Jewaragi	14.87	12.67	10.25	6.35	6.32	0	4.14
8		Aurad	6.32	2.35	14.74	15.36	25.14	0	0
9		Kellur	13.66	0	20.33	8.52	11.06	0	0
10		Chigralli	12.37	0	21.06	12.38	5.25	4.25	0
11		Madbal B	5.66	0	14.36	9.36	17.25	0	5.32
12		Nalwar	8.25	**19.36**	**12.58**	**6.31**	**6.52**	**6.35**	0
13		Wadi	**10.36**	**0**	**5.25**	12.52	12.52	4.28	0
14		Wadi-II	12.25	0	14.25	17.54	6.35	3.21	2.33
15		Chittapur	12.65	10.25	5.36	19.65	12.31	0	12.3
16		Dhandothi	6.58	14.25	12.52	5.36	14.32	3.25	10.02
17		Tengli cross	9.85	3.25	16.35	12.14	6.54	5.24	12.36
18		Malkhed	10.36	8.21	19.25	9.25	10.23	4.01	15.66
19		Neelahalli	8.08	5.36	26.32	14.27	14.25	0	19.36
20		Survar	12.3	8.45	19.61	15.33	9.65	0	8.52
21		Kodla	9.52	10.25	21.02	6.32	4.12	0	12.32
22		Madbol	10.25	6.32	23.25	17.16	8.52	5.37	10.36
23		Ravoor	15.32	12.77	17.88	9.65	15.66	8.12	16.29
24		Sahabad	12.45	10.93	9.33	6.07	18.54	0	14.27
25		Devanateganur	4.69	15.6	12.3	4.66	23.54	0	12.63
26		Teganur	8.51	0	13.25	12.58	21.82	9.36	9.31
27		Nandur	12.05	0	15.41	17.62	18.54	2.24	12.3
28		Sannur	14.62	6.36	10.29	15.45	13.25	7.62	0
29		Uplaon	8.45	18.25	9.36	18.37	10.41	2.15	0
30		Awarad	3.68	5.36	0	12.36	9.54	10.53	8.63
31		Ankalaga	12.22	14.36	14.25	17.21	14.26	0	12.3
32		Mahagaon	14.55	5.32	13.65	20.14	22.34	0	6.11
33		Navadgi	10.32	9.66	15.92	13.48	14.58	0	0
34		Kamalapur	13.25	6.15	20.36	17.62	22.19	6.32	0
35		Hallikhed K	8.24	12.36	14.58	14.28	12.42	11.19	0

Table 1 continued...

Table 1 continued...

36		Tajsultanpur	14.25	0	10.49	11.34	22.04	0	15.33
37		JamagaB	9.37	3.25	15.66	17.39	12.46	12.36	8.66
38		Kallahangarga	10.35	0	13.21	9.33	14.78	5.45	5.32
39		Chinhcnasur	9.61	0	16.48	5.25	12.39	6.48	0
40		Bhosga	8.51	12.36	19.51	12.69	16.55	2.21	0
41		Suntanoor	13.66	3.65	20.36	22.35	25.21	0	10.32
42		Pattana	12.36	8.54	19.13	18.52	21.36	3.74	9.11
43		Pattana toll	9.65	13.42	20.31	20.31	18.55	7.50	2.46
44		Kadaganchi	16.02	10.09	0	19.04	16.22	9.32	0
45		Nellur	12.82	13.15	23.65	13.25	17.06	5.21	0
46		Aland	9.32	9.64	19.04	23.47	14.33	0	3.62
47		Shakapur	14.67	5.08	20.34	15.22	9.65	0	2.15
48		Khanapur	12.36	10.44	9.61	9.32	12.41	3.27	0
49		Korhalli	6.41	6.32	13.37	15.32	14.35	6.14	2.63
50		Bhoosnur	17.95	0	10.25	23.01	15.04	10.92	4.55
51		Dangapur	15.24	0	11.92	18.65	14.26	6.12	10.25
52		Nimbarga	21.02	12.25	14.58	14.29	13.74	6.47	13.66
53		Ganagapur St	15.25	0	12.69	20.41	16.27	10.69	9.16
54		Afzalpur	6.31	3.65	18.16	14.82	12.36	8.4	10.31
55		Malhabad	12.25	4.58	20.33	16.33	20.14	4.65	9.63
56		Atanoor	14.85	11.25	8.41	14.75	23.38	0	0
57		Chawadapur	9.66	6.47	15.34	20.36	18.25	0	2.38
58		Gobburwadi	12.04	7.05	20.36	14.26	14.21	6.32	9.14
59		Gobbur B	17.25	11.18	18.45	9.62	16.56	0	10.33
60		Gobbur K	9.45	12.95	10.36	12.35	12.39	5.28	7.34
61		Sirasagi	12.74	4.52	12.66	14.22	10.33	2.61	0
62		Nandikoor	10.52	12.36	18.75	10.35	14.82	0	0
63		Sonna	8.86	10.76	19.85	14.55	18.66	0	0
64		Mandewal	14.22	8.54	20.17	16.32	10.36	0	13.52
65		Jeratagi	9.36	12.93	16.32	14.25	16.32	12.36	5.41
66		Ratkal	12.82	17.33	9.12	10.5	23.25	10.25	6.32
67		Kodli	8.12	10.23	15.67	16.54	18.21	6.32	1.25
68		Sulepeth	12.63	6.01	16.44	14.22	14.69	2.33	0
69	Yadgir	Maddarki	8.69	5.28	12.14	16.54	10.25	6.31	0
70		Doranahalli	10.24	0	0	8.41	8.52	0	0
71		Gundahalli	4.66	14.25	3.58	7.56	11.36	0	2.52
72		Khanapur	12.36	8.25	8.52	10.09	9.64	3.38	1.32
73		Naikal	11.05	12.36	12.45	18.64	10.25	0	12.01
74		Yadgir	10.05	18.36	9.65	14.22	15.65	0	6.04
75		Yaragol	11.9	8.25	10.43	8.45	20.3	0	5.21

Table: 2 spatial distribution of different disease of pigeonpea in North Karnataka during 2024

S. no.	Districts	Name of the place	Per cent disease incidence (%) / Percent Disease Index (PDI)						
			Wilt	SMD	PSB	DRR	MSB	CLS	ALS
			% incidence					PDI	
1	Kalaburagi	Shaikroza	6.85	0	14.25	12.39	7.32	3.69	0
2		Pattan	8.36	2.28	12.74	18.52	10.25	8.52	15.33
3		Suntanoor	6.52	0	8.36	25.3	12.36	2.35	12.37
4		Kadaganchi	8.36	0	26.32	36.55	14.25	6.51	22.31
5		Aland	12.36	2.58	14.36	41.25	11.95	1.25	23.25
6		Korahalli	6.15	5.39	18.21	23.65	14.25	5.33	18.65
7		Dangapur	9.36	2.58	24.15	20.58	12.36	6.31	13.69
8		Nimbaraga	6.04	3.61	11.07	26.32	14.77	2.84	24.15
9		Gobbur B	2.36	2.17	16.98	19.06	12.36	5.69	28.25
10		Chawadapur	8.96	7.18	14.32	21.36	15.47	2.05	19.36
11		Bhairamadagi	2.36	1.36	18.25	12.44	10.87	4.58	18.25
12		Atanoor	6.39	0	17.25	22.47	12.49	2.87	25.36
13		Afzalpur	8.52	2.36	5.89	13.79	15.64	2.14	28.36
14		Devanagaon	3.69	7.41	14.61	16.28	12.07	26.35	42.58
15		Harnal	0.54	8.99	8.32	8.56	11.06	16.91	8.41
16		Sirnoor	6.96	8.34	10.32	12.98	8.47	9.37	22.14
17		Farhatabad	2.32	2.17	20.27	8.74	14.74	5.69	35.25
18		Raddewadagi	9.61	8.74	21.94	11.74	17.61	14.33	17.65
19		Jewaragi	5.41	3.92	18.03	6.88	12.36	9.82	21.54
20		Jeratagi	3.28	6.27	6.81	9.32	6.88	10.28	24.1
21		Chigarahalli	6.98	11.05	7.21	6.32	8.21	12.44	17.25
22		Hulkal	5.36	17.25	8.14	4.25	13.58	7.14	9.32
23		Awarad B	10.28	18.32	24.18	12.04	14.36	17.41	21.17
24		Kurikota	12.36	7.12	17.41	17.82	11.45	9.14	13.28
25		Mahagaon	8.25	17.35	24.17	13.28	14.22	8.32	24.17
26		Kamalapur	6.98	10.44	17.28	11.32	6.25	13.67	21.04
27		Hallikhed	7.32	3.25	22.87	21.05	19.25	4.21	8.25
28		Humnabad	3.25	22.14	10.85	12.28	9.32	9.74	14.22
29		Chitagoppa	2.58	6.98	18.25	8.05	10.25	12.41	32.25
30		Ratkal	4.25	8.25	14.84	8.52	6.28	23.17	41.25
31		Kodli	7.12	0	25.39	10.25	12.47	12.69	35.21
32		Tengli	2.07	3.44	12.47	14.52	16.38	8.41	20.41
33		Malkhed	8.66	12.36	37.05	8.14	8.25	10.47	19.32
34		Gundagurti	5.28	8.52	19.25	10.32	6.39	11.55	17.45
35		Madbol	6.33	10.25	13.47	9.21	15.47	15.78	20.14
36		Sangavi	7.08	2.36	22.14	12.14	13.25	6.32	8.52

Table 2 continued...

Table 2 continued...

37		Sedum	1.25	23.14	14.07	4.21	15.28	17.12	32.45
38		Kodla	6.32	12.87	20.14	17.25	5.25	8.54	21.3
39		Betgera K	12.58	2.58	9.52	23.14	10.74	12.14	7.51
40		Chittapur	4.17	8.41	12.44	18.41	17.41	12.85	6.25
41		Ravoor	12.41	8.14	21.45	14.25	12.69	10.22	8.54
42		Malagatti	4.39	12.22	28.54	10.25	16.58	5.47	12.36
43		Shahabad	6.47	10.28	33.21	18.52	14.58	9.28	11.47
44		Korwar	3.75	5.17	11.07	13.25	6.54	8.41	12.51
45		Chincholi	6.58	2.44	25.01	10.44	14.2	6.52	13.54
46	Vijayapur	Almel	1.58	9.54	3.21	5.69	5.78	11.08	39.05
47		Korahalli A	2.15	6.69	0	8.21	3.76	13.03	27.21
48		Rampur	4.67	10.43	3.46	4.75	8.54	15.64	62.25
49		Sindagai	1.45	9.03	1.53	8.52	11.32	14.23	26.67
50		Bandyal	3.22	13.98	5.22	17.01	2.14	22.1	36.21
51		Budihal	2.05	6.72	0	12.25	5.43	15.39	25.54
52		Gabbasavalagi	2.36	8.54	4.28	6.17	8.74	8.74	32.81
53		Shivanagi	2.79	8.66	1.28	3.74	9.87	8.47	21.04
54		Hadagali	6.98	3.28	1.74	7.31	7.12	6.08	18.47
55		Honnuatagi	2.39	8.11	4.69	8.24	6.98	13.28	21.36
56		Kavalagi	1.93	1.08	0	7.41	12.37	11.34	13.74
57		Tidagundi	3.77	6.21	0.74	8.52	2.44	27.41	41.28
58		Kannur	1.08	0	0	9.41	5.28	18.37	35.27
59		Horti	3.28	0	5.14	4.85	4.58	21.19	65.25
60		Savalasang	0.25	0	0	3.67	5.36	17.85	54.81
61		Inchageri	3.69	0	0	4.12	4.81	23.69	45.28
62		Koluragi	2.36	0.85	0	8.41	6.74	13.45	38.69
63		Chawdihal	3.98	5.27	0	4.05	7.82	9.12	44.19
64		Indi	2.18	3.65	0	8.41	12.74	24.94	36.58
65		Korahalli	3.78	7.41	2.36	4.27	13.28	9.48	37.12
66		Huvinhalli	4.08	3.78	8.58	8.14	6.25	21.08	31.07
67		Hittanahalli	3.69	7.45	2.05	7.32	7.56	14.25	18.24
68		Managuli	1.08	12.33	1.28	4.18	4.69	18.56	37.25
69		Satihal	3.28	4.7	8.45	7.18	2.87	24.16	31.08
70		Dindawar	2.15	9.25	4.15	8.08	7.11	12.74	39.54
71		Huvinahipparagi	3.28	0.41	0	4.25	5.17	24.17	27.68
72		Hunshyal	1.08	4.28	2.07	7.41	11.25	38.25	43.21
73		Bagewadi	6.32	2.01	3.58	9.24	4.12	12.74	67.54
74		Yarnal	2.14	0	0	7.54	6.39	25.36	84.25
75		Yalwar	2.61	0.25	0	8.52	5.14	32.15	69.84

Table 2 continued...

Table 2 continued...

76		Kadkol	5.21	0	2.25	5.33	9.32	24.84	67.14
77		Kesratagi	2.14	1.25	0	8.52	8.44	23.14	74.25
78		Talikoti	4.25	0.5	0	2.36	14.25	12.08	64.25
79		Muddebihal	1.25	8.12	3.25	6.08	8.25	25.14	32.05
80		Dhavalagi	8.25	2..6	0	4.08	7.22	24.69	38.14
81		Kallahangaraga	8.36	2.33	7.14	10.25	2.36	17..25	28.14
82		Mandewal	4.85	9.25	4.18	8.04	7.17	12.34	22.45
83		Satihal	2.25	2.36	0	3.25	3.6	12.36	85.25
84		Ramanagar	2.12	10.25	0	4.12	12.02	20.14	63.14
85		Ingleshwar	1.28	3.69	0	4.95	8.54	23.49	74.58
86		K salawadagi	3.45	8.12	0	1.25	2.36	21.25	54.25
87		Arali chandi	1.02	15.22	0	6.01	6.57	14.78	70.14
88		Karbhantanal	5.33	6.25	2.52	5.12	8.21	16.28	51.33
89		Agasbal	2.71	7.02	2.3	3.25	5.07	19.45	42.36
90		Basarkod	5.19	5.21	0	8.14	6.33	11.28	53.47
91		Gonal	3.62	3.25	2.14	6.84	4.02	23.15	32.14
92	Yadgir	Vibhootihalli	3.25	7.12	0	12.58	6.25	9.31	11.45
93		Hattigudur	9.25	0	0	8.66	5.25	10.47	14.31
94		Kongandi	2.28	0	1.05	7.41	6.33	21.36	74.21
95		Devikera	6.35	0	0	5.36	3.25	12.36	36.25
96		Surpur	4.17	2.36	0	4.11	58.88	23.14	45.12
97		Kawadimatti	2.36	8.52	3.25	12.39	10.25	12.36	18.25
98		Devapur	3.98	12.36	1.22	10.41	9.12	17.54	36.25
99		Kakkera	4.66	35.21	3.64	8.25	7.36	28.17	44.51
100		Rajankolur	0.20	32.01	5.12	4.36	11.25	17.85	27.14
101		Kodekal	2.58	14.25	0	9.37	5.41	13.36	75.25
102	Raichur	Mailapur	3.68	5.21	1.25	8.12	6.28	15.22	65.28
103		Rodalbanda	12.25	1.02	3.22	10.23	4.33	22.84	44.58
104		Yargunti	8.52	4.58	5.41	8.54	9.12	12.57	18.25
105		Eichanaltanda	6.85	5.81	0	10.25	0	21.04	30.14
106		Lingasgur	5.36	10.84	2.22	6.33	0	12.84	41.07
107		Sarjapur	11.25	9.25	0	5.88	3.25	11.47	62.35
108		Santekallur	6.35	0	2.58	8.52	6.08	21.55	37.54
109		Ankushdoddi	1.25	0	0	2.58	3.58	23.58	58.36
110		Buddinni	2.25	0	0	5.36	5.32	12.05	42.25
111		Maski	1.42	0	0	7.11	10.98	10.36	58.65
112		Gudadur	2.84	2.36	0	5.21	9.24	8.52	35.22
113		Rangapur	6.32	0	5.22	10.25	5.27	11.48	51.25
114		Honnahalli	1.44	0	1.84	6.35	4.51	10.31	53.25
115		Gurgunta	8.19	0	0	1.22	8.11	8.25	24.25

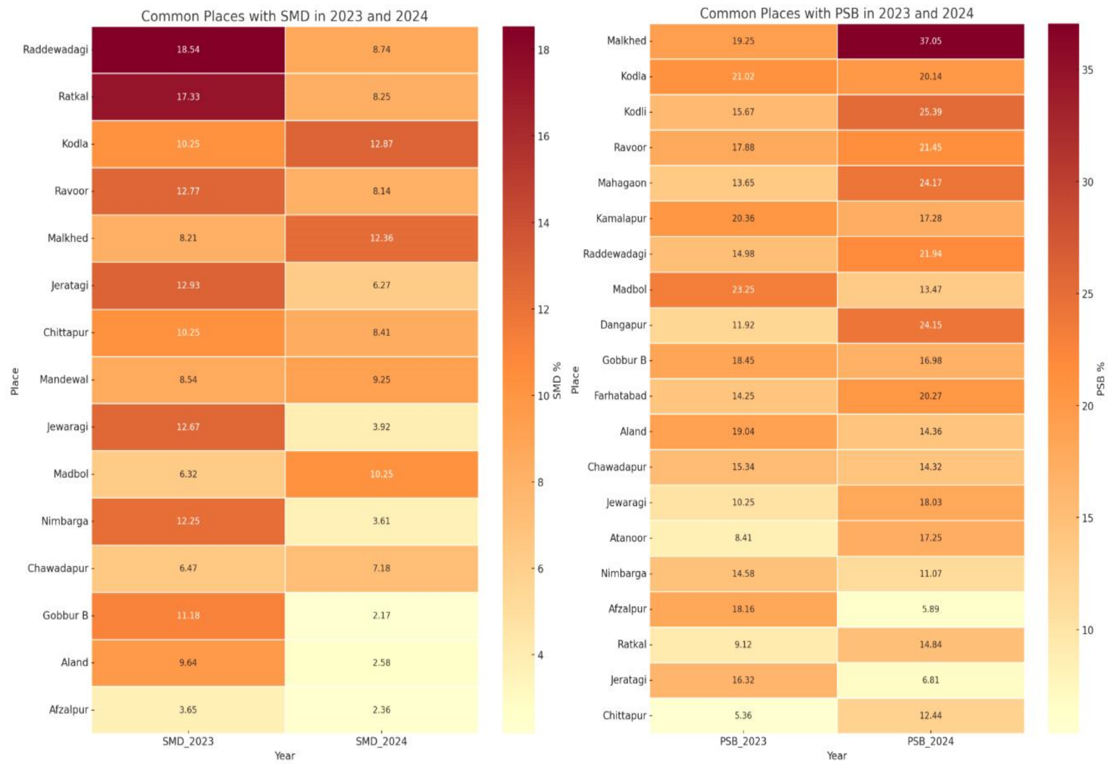

Fig. 5 : Heat map showing SMD & PSB incidences on same places during 2023 & 2024.

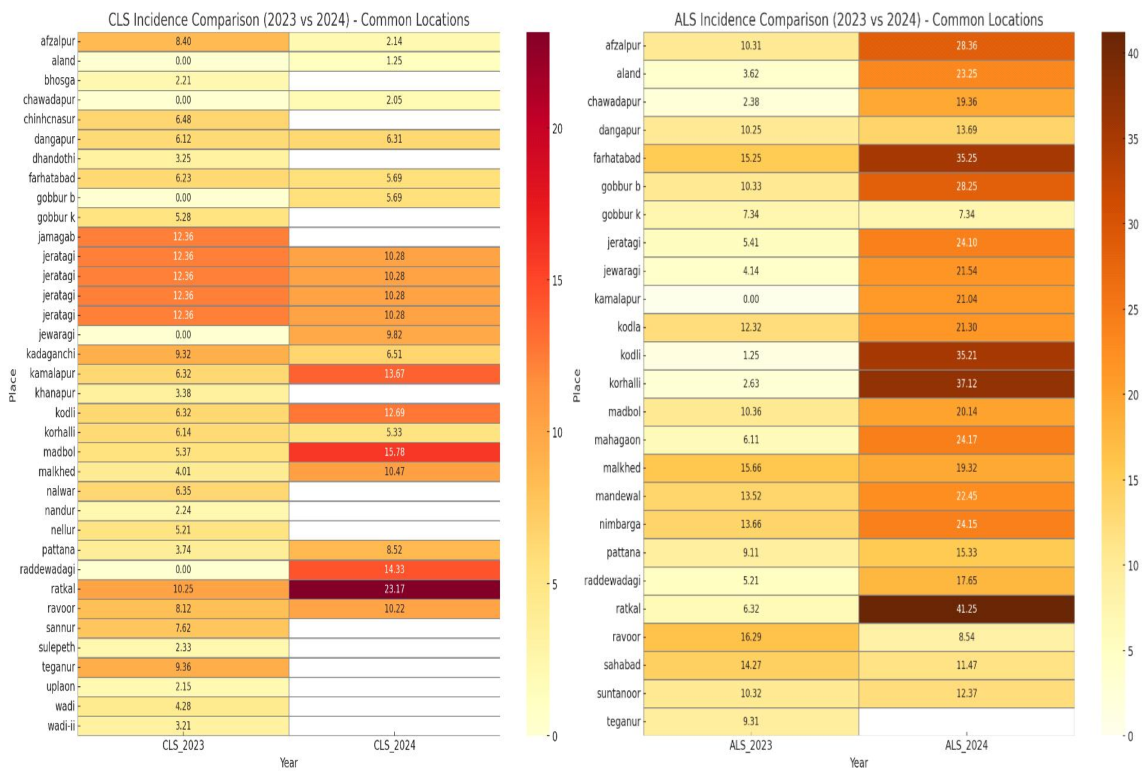

Fig. 6 : Heat map showing CLS & ALS incidences on same places during 2023 & 2024.

Sterility Mosaic Disease: Sterility Mosaic Disease, caused by *Pigeonpea sterility mosaic virus* and transmitted by the eriophyid mite *Aceria cajani*, exhibited erratic and location-specific patterns over the two years. In 2023, SMD incidence ranged from 0 to 19.36 per cent, with maximum incidences at Nalwar (19.36%), Raddewadagi (18.54%) and Ankalaga (14.36%). Other affected villages included Jewaragi, Ravoor and Devanateganur, with incidences exceeding 10 per cent.

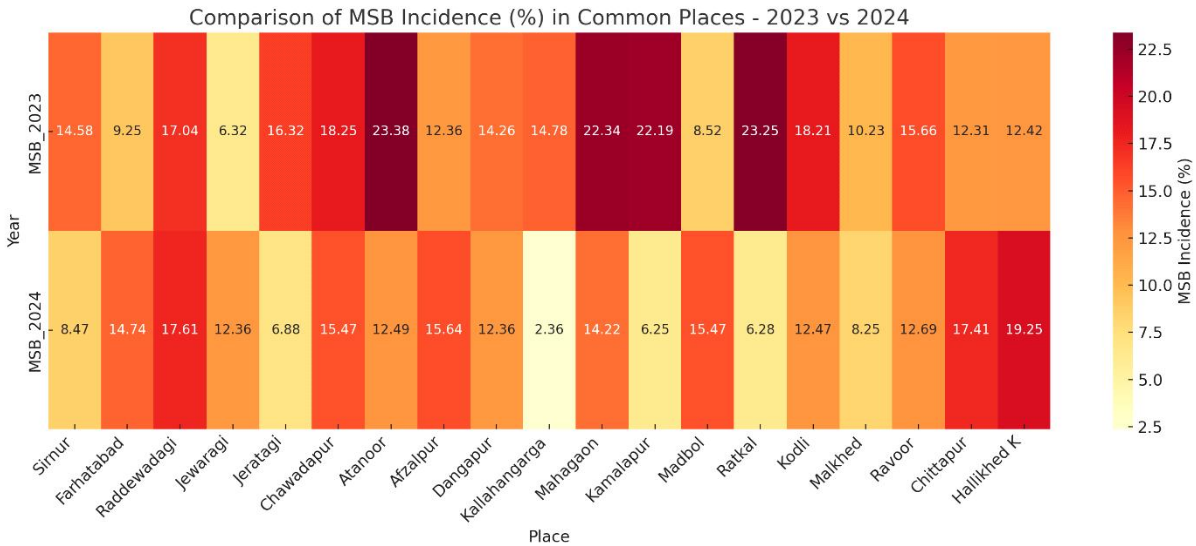

Fig. 7 : Heat map showing MSB incidence on same places during 2023 & 2024.

In contrast, the 2024 survey recorded SMD incidence from 0 to 23.14 per cent, with several areas reporting fresh outbreaks. Sedum (23.14%), Mahagaon (17.35%), Humnabad (22.14%), Kadaganchi (17.25%) and Ratkal (17.33%) emerged as notable hotspots. Although the average incidence was relatively similar to 2023, the disease appeared in newer villages, suggesting increased mite movement and possible varietal susceptibility.

The year-wise fluctuation in SMD incidence is strongly influenced by early season rains followed by dry spells, favouring vector proliferation and spread of PPSMV. Studies by Nene *et al*. (2012) and Sharma *et al*. (2021) highlight the significant role of volunteer pigeonpea plants and ratoon cropping systems in maintaining the virus inoculum between seasons. Moreover, higher SMD incidence in 2024 could be linked to delayed sowing in some regions, allowing for synchronization of young crop stages with peak mite population activity. Secondly many pigeonpea plots with high SMD were surrounded by sugarcane and irrigated crops which will definitely help in build-up of high humidity requited for faster perpetuation of the vector population. The symptoms expression is also favoured by this kind of weather.

The expansion of SMD incidence in 2024 reaffirms earlier predictions by Sharma *et al*. (2020) and recent reports by ICAR-IIPR (2023), which emphasized its re-emergence as a serious issue under changing climate scenarios, characterized by increased temperature and intermittent rains during crop establishment and vegetative phases.

Phytophthora Stem Blight (PSB): Phytophthora stem blight, caused by *Phytophthora cajani*, continued its emergence as a rapidly escalating foliar and stem disease in the surveyed regions. In 2023, PSB incidence varied from 5.25 to 26.32 per cent, with Neelahalli (26.32%), Navadgi (23.25%) and Mahagaon (22.34%) reporting the highest incidences. Other locations such as Suntanoor (25.21%) and Devanateganur (23.54%) recorded significant disease severity, particularly during flowering to podding stages when intermittent rains were received.

In 2024, PSB incidence increased alarmingly across several villages, ranging from 3.21 to as high as 37.05 per cent in Malkhed, followed by Shahabad (33.21%), Kadaganchi (26.32%), and Aland (24.36%). Suntanoor (25.21%) and Mahagaon (24.17%) also remained consistent PSB hotspots during both years. This is mainly due to this entire region received heavy rains during both the years and high rainfall with water stagnation for more than three to four days was frequently observed. Deep black soils, plots with no proper drainage having completely saturated soil moisture favoured the heavy incidence of PSB.

The overall increase in PSB incidence during 2024 can be directly linked to abnormal rainfall events during September-October, resulting in high soil and canopy moisture. This aligns with observations by Sharma and Pande (2020) and Reddy *et al*. (2023), who reported that frequent rains coupled with poorly drained Vertisols create ideal conditions for Phytophthora outbreaks. Additionally, reduced field sanitation, dense plant populations, and the absence of resistant varieties exacerbated disease levels in certain villages.

Earlier reports by Pande *et al*. (2020) and ICAR-IIPR (2023) highlighted that Phytophthora stem blight is

Plate 1 : Severe incidence of pigeonpea Phytophthora stem blight due to heavy rains.

Plate 2 : Severe incidence of pigeonpea Phytophthora stem blight due to heavy rains.

Plate 3 : Complete wilting of pigeonpea due to combined incidence of Phytophthora stem blight & dry root rot diseases.

an emerging and fast-spreading constraint in southern India, with projections of it becoming a major yield-limiting disease in pigeonpea belts under a changing climate. The data from both years substantiates this concern, with both the spatial spread and intensity of PSB showing upward trends.

Macrophomina Stem Blight: The incidence of Macrophomina Stem Blight (MSB) in pigeonpea showed considerable spatial and temporal variation across different locations in North Karnataka during the 2023 and 2024 kharif seasons. In 2023, MSB severity ranged from 4.12 to 25.21 per cent, with the highest incidence observed at Suntanoor (25.21%), followed by Aurad (25.14%), Teganur (21.82%) and Devanateganur (23.54%). Similarly, in 2024, MSB disease pressure remained widespread, with Surpur (58.88%), Hallikhed (19.25%), Chittapur (17.41%) and Ravoor and Madbol(15.47%) emerging as critical hotspots for the disease.

Comparatively, the disease intensity during 2024 was notably higher in several locations, especially in Surpur, where MSB PDI (Per cent Disease Incidence) reached nearly 59 per cent, suggesting favorable microclimatic conditions, crop management practices, or varietal susceptibility in these areas. Locations such as Mahagaon, Awarad B, Aland, and Chawadapur also recorded consistent MSB presence above 14 per cent, indicating a recurring pattern of high disease pressure in the Kalaburagi and Bidar regions.

The widespread incidence of MSB across both years aligns with earlier studies that highlight the pathogen's ability to thrive under humid and warm conditions, particularly in high-density pigeonpea stands (Rao *et al*., 2016 and Sharma *et al*., 2020). The increased intensity observed in certain localities during 2024 may be attributed to climatic variability, such as prolonged periods of leaf wetness and intermittent rains during the flowering to pod development stages, which are known to favor MSB development (Patil *et al*., 2021).

Furthermore, differences in disease severity across years and locations may also reflect differences in genotype susceptibility, crop age, and agronomic practices. The high incidence in locations like Surpur and Ratkal over consecutive years suggests the presence of inoculum carry-over and inadequate disease management practices, such as the lack of crop rotation and use of local susceptible varieties.

Field observations also indicate that stem lesions and dieback symptoms were more pronounced in areas where MSB was above 15 per cent incidence PDI, potentially impacting yield directly through impaired nutrient transport and increased lodging, as supported by earlier findings (Reddy *et al*., 2014 and Kumar *et al*., 2017).

Given the increasing trend and severity of MSB in pigeonpea growing belts of North Karnataka, integrated disease management strategiesincluding the use of resistant cultivars, proper crop spacing, and timely fungicidal applicationsare urgently required. Mapping of disease hotspots, as done in this study, can assist in

Plate 4 : Severe incidence of Dry Root Rot in pigeonpea.

Plate 5 : Severe incidence of ALS and CLS on rachis and stem of pigeonpea plants.

targeted interventions and forecasting models.

Alternaria Leaf Spot (ALS): In 2023, Alternaria Leaf Spot incidence was comparatively lower and localized, ranging from 0 to 19.36 per cent. Notable hotspots were observed in Neelahalli (19.36%), Farhatabad (15.25%) and Malkhed (15.66%), primarily during the pod development stage. The disease appeared as small, circular to oval, dark brown necrotic spots with concentric rings, often leading to premature leaf drop in severe cases.

In sharp contrast, during 2024, ALS incidence increased markedly, ranging from 7.51 to84.25 per cent. Extremely high incidences were recorded in Yarnal (84.25%), Rampur (62.25%), Horti (65.25%), Surpur (45.12%) and Chawadapur (19.36%) villages. This substantial escalation can be attributed to prolonged monsoon rains, elevated relative humidity, and intermittent dry spells, which favour the sporulation and spread of *Alternaria alternata* conidia (Sharma and Pande, 2020; Pande *et al*., 2020).

The disease was found predominantly in fields with dense canopy cover, poor aeration, and continuous pigeonpea cultivation conditions known to facilitate pathogen perpetuation and foliar disease spread (Rameshwar *et al*., 2022). Similar increases in ALS severity under changing climatic conditions have been noted by ICAR-IIPR (2023). During 2024, monsoon was extended by more than 18 days. After mid October, heavy fog formation was witnessed across the diseased area and it favoured the surge in the leaf spot incidence. Infections on rachis, peduncle and young stems led to heavy flower and pod drop causing 34 to 78 per cent yield losses among the plots surveyed.

Cercospora Leaf Spot: The incidence of Cercospora Leaf Spot (CLS) showed a modest presence in 2023, ranging from 0 to 12.36 per cent. The highest incidence was recorded in Hallikhed K(11.19%), with sporadic occurrences in Suntanoor (12.36%) and a few other locations. Symptoms typically appeared as small, irregular brown lesions surrounded by chlorotic halos, causing premature senescence in older leaves.

However, in 2024, CLS incidence rose dramatically, ranging from 1.25 to 38.25 per cent. The highest incidences were noted in Hunshyal (38.25%), Yarnal (25.36%), Horti (21.19%), andKongandi (21.36%). This upward trend aligns with the findings of Sharma *et al*. (2021), who emphasized the role of high humidity (>85%) coupled with moderate temperatures (26–30°C) in promoting CLS development.

The extensive spread of CLS in 2024 coincided with regions of dense intercropping, poor crop rotation and high crop residue load, suggesting that lack of stubble management might have contributed to increased primary inoculum (Pande *et al*., 2020). Further in 2024 monsoon season got prolonged and also vegetative growth of the pigeonpea. In many areas heavy fog formation during October end led to severe outbreak of CLS along with ALS and infection on rachis and flower buds lead to severe yield losses ranging from 6.51 to 85.00 per cent.

The pattern is consistent with observations by Rameshwar *et al.* (2022) regarding the role of field microclimates and continuous pigeonpea cultivation in disease persistence and epidemics.

Dry Root Rot (DRR): The disease is caused by *Macrophomina phaseolina*, emerged as a consistent and widespread problem across both survey years. In 2023, incidences ranged from 4.66 to 23.47 per cent, with highest severity observed at Aland (23.47%), Mahagaon (20.14%), Bhoosnur (23.01%) and Ankalaga (17.21%). The disease incidence was notably higher during flowering to maturity stages, particularly in fields subjected to terminal moisture stress and high soil temperatures.

Table 3 : Maximum and minimum incidences of each disease in surveyed districts of North Karnataka during 2023.

District	Wilt (%) max	Wilt (%) min	SMD (%) max	SMD (%) min	PSB (%) max	PSB (%) min	MSB (%) max	MSB (%) min	ALS (PDI) max	ALS (PDI) min	CLS (PDI) max	CLS (PDI) min	DRR (%) max	DRR (%) min
Kalaburagi	21.02	3.68	19.36	0	26.32	0	25.21	4.12	19.36	0	12.36	0	23.47	4.66
Yadgir	12.36	4.66	18.36	0	23.67	0	20.3	6.32	15.25	0	6.31	0	18.64	5.36

Table 4 : Maximum and minimum incidences of each disease in surveyed districts of North Karnataka during 2024.

District	Wilt (%) max	Wilt (%) min	SMD (%) max	SMD (%) min	PSB (%) max	PSB (%) min	MSB (%) max	MSB (%) min	ALS (PDI) max	ALS (PDI) min	CLS (PDI) max	CLS (PDI) min	DRR (%) max	DRR (%) min
Kalaburagi	12.58	0.54	23.14	0	37.05	5.89	19.25	5.25	42.58	0	26.35	1.25	41.25	4.21
Vijayapur	8.36	0.25	15.22	0	8.58	0	14.25	2.14	85.25	13.74	38.25	6.08	17.01	1.25
Yadgir	9.25	0.20	35.21	0	5.12	0	58.88	3.25	75.25	11.45	28.17	9.31	12.58	4.11
Raichur	12.25	1.25	10.84	0	5.41	0	10.98	0	65.28	18.25	23.58	8.25	10.25	1.22

Plate 6 : Incidence of ALS and CLS on leaves of pigeonpea plants.

In 2024, DRR incidence increased sharply, ranging from 1.22 to 41.25 per cent. The highest incidences were reported at Aland (41.25%), Kadaganchi (36.55%), Nimbaraga (26.32%), Surpur (45.12%) and Horti (21.05%). This pattern corroborates with the predictions made by ICAR-IIPR (2023) and Sharma *et al*. (2021), who anticipated DRR escalation under climate change scenarios characterized by erratic rainfall and terminal drought spells. In the present study also incidences of DRR are noticed on light and shallow soil both in 2023 and 2024 (Fig. 4) and are coupled with wilt and PSB also leading to wilt complex due to multiple pathogens.

The pigeon requires adequate moisture during the phase of filling its vital pods, which usually occurs in the month of November. In earlier years, North Karnataka - Especially the districts of Kalaburagi, Yadgir, Bidar, and Raichur - during this period, assurance between 20 and 40 mm is used to receive rain. This rain played an important role in supporting healthy crop development and ensuring proper grain filling. However, in recent years, the impact of climate change has changed this pattern significantly. During November, the rain has either stopped completely or has become extremely scary and irregular. This sudden change in climate behavior has produced dried mantras for a long time during the maturity phase of the crop, which has increased the vulnerability of the pigeon to dry root rot (DRR). Lack of moisture stress during this important phase weakens the protection mechanism of the plant, making it more susceptible to the outbreak of DRR. Consequently, the occurrence of the disease has intensified in major pigeon-enthusiasts, which is a serious danger to achieve stability and long-term productivity. This trend highlights climate-flexible disease management strategies and immediate needs of better water conservation practices to protect pigeon cultivation in northern Karnataka.

The spatial distribution showed severe incidences in Kalaburagi, Raichur and Vijayapur districts, particularly in sandy loam soils prone to rapid moisture depletion a condition that favours *M. phaseolina* survival and infection (Pande *et al*., 2020). These findings affirm reports by Rameshwar *et al.* (2022) on the increasing prominence of DRR in pigeonpea-growing belts of peninsular India. In the present study also Aland, Afzalpur, Jewaragi and Kalaburagi talukas having light and sandy soils lost soil moisture very early and there was dry spell during post flowering this led to aggrieved situation and severe outbreak of Dry Root Rot in both the years. Another reason for such high incidence of DRR was, monocropping coupled with infested crop residues of previous season are adding more pathogen to the soil. There is also very poor carbon content in the soil. Mechanised harvesting of pigeonpea is another reason adding infested plants and their stems back in to the same plot increasing the incidence of DRR each year. Lastly there is no single cultivar cultivated resistant to either Phytohothra blight or Dry Root Rot diseases, this situation warrants urgent identification and development of integrated disease management strategies for sustainability of pigeonpea in North Karnataka.

Conclusion

The combined analysis reveals that ALS, CLS and DRR incidences have increased significantly from 2023 to 2024, underlining the growing threat of foliar and soilborne diseases in pigeonpea cultivation under changing climatic patterns. While ALS and CLS flourished in high humidity and dense canopies, DRR thrived underterminal drought and soil moisture fluctuations.

These findings highlight the urgent need for integrated disease management (IDM) strategies combining resistant varieties, optimum plant density and spacing, Timely fungicideapplications (for foliar diseases), crop residue management, soil moisture conservation practices and crop rotation with non-host species. Furthermore, regional disease surveillance, forecasting systems and farmer advisories must be strengthened to mitigate future epidemics.

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