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Occurrence and Distribution of Lentil Wilt in Major Lentil Growing Regions of Madhya Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In the present investigation, roving survey was conducted during the October to February of 2020–2021 and 2021–22 to acquire information on the natural disease incidence and distribution of lentil wilt in the farmers' fields in eight different districts of Madhya Pradesh. A pooled mean of disease incidence ranging from 6.62%–20.36% was observed during 2020–22. The district wise scenario of lentil wilt over a period of two consecutive years revealed that maximum average incidence of 18.96% was recorded in Sagar district followed by 17.67% in Khandwa district. However, minimum average wilt incidence of 12.17% was recorded in Mandla district followed by 12.55% in Jabalpur district. Looking to the occurrence of lentil wilt, Sagar, Khandwa, Damoh, Katni and Dindori were identified as hotspot pockets for occurrence of lentil wilt in surveyed districts of Madhya Pradesh. Further, reduction of 26.28% in wilt occurrence was recorded in the farmers' practice advocated as seed treatment before sowing. Under the seven cropping patterns observed, the minimum wilt incidence of 13.96% was recorded in rice followed by lentil which is the most predominant cropping pattern across the surveyed locations. Further different varieties were screened for occurrence of lentil wilt at Sagar. Among the 14 varieties, maximum incidence of lentil wilt was recorded in PL 5 followed by Shekhar masoor 3. However, two varieties namely JL 1 and L 4076 were found free from wilt incidence in selected hot spot pocket for lentil wilt.

Keywords: Cropping pattern; disease incidence; Fusarium wilt; lentil and seed treatment.

1. INTRODUCTION

Lentil (*Lens culinaris* Medik) is a major edible legume crop after chickpea and is commonly known as masoor or poor man's meat [1]. It is a cool season, diploid (2n=2X=14), self-pollinating grain legume crops with genome size of approximately 4 Gb [2]. Lentil is an ancient crop originated in the Near East and after that rapidly spreaded all through the Mediterranean Basin, Central Asia and later to the New World including Latin America [3,4].

Lentil is recognized as one of the most nutritious pulse crops ranking next to chickpea amongst *rabi* pulses. Lentil seed contain 28.3% protein, 55.3% carbohydrate, 2.1% total lipids, 8.5% fiber, 5.3% ash and different minerals including K, P, Fe, and Zn. Due to low glycemic index, it was highly recommended by physicians for the people suffering from diabetes, obesity, and cardiovascular diseases [5,1,6] Globally, lentil was cultivated in about 4.8 mha area with an annual production of 5.73 mt and with an average productivity around of 1193 kg ha^{-1} [7,8].

It was grown on 1.51 mha area with an annual production of 1.56 mt with a productivity of around 1032 kg ha^{-1} during 2018–19 in India, Madhya Pradesh ranks first in area *i.e*., 37.02% followed with the aid of UP 31.46% and West Bengal 12.23% and in terms of production M.P. ranks first at 41.05% accompanied with the aid of Uttar Pradesh 31.27% and West Bengal 11.02% in terms of production. The absolute best yield was recorded by the state of Rajasthan (1162 kg ha^{-1}) followed by Madhya Pradesh (1145 kg ha^{-1}) and Uttar Pradesh 1026 kg ha^{-1} [7].

Lentil production is challenged by a wide range of pathogens [9] Among the different diseases of lentil *viz*., Fusarium wilt, Collar Rot, Root Rot, Alternaria blight, Rust, Ascochyta Blight, Botrytis gray mold and Sclerotinia stem rot, wilt is major limiting factor in its production and productivity [10] Lentil wilt, caused by *Fol*, is a widespread disease of lentil with its report of occurrence from as many as 26 countries in South Asia, Sub-Saharan Africa and West Asia and North Africa (WANA) regions [11,12]. Several management strategies have been advocated for eco-friendly management of plant diseases. Under eco-friendly management tactics [13,14]. Survey has been conducted by several workers in India and other countries to document the status of lentil wilt.

Chaudhary et al. [15] conducted a survey of 116 districts in 9 lentil growing states covering 603 farmers' field revealed a range of (0.7–9.3%) plant mortality at reproductive stage with *Fol* causing (62%) of the overall mean mortality of (6.3%). Merzoug et al. [16] and Khare et al. [17] conducted survey during the period 2007–11 in four different Agro-climatic zone and proved pathogenic variability in 52 isolates of *F. oxysporum* f.sp. *lentis*.

Wilt incidence at seedling stage can lead to a complete crop failure whereas at adult stage

(flowering and podding) infection, the plants are able to produce some grain yield that could be shriveled. Wilt incidence as high as 50–78% has been reported in some fields of M.P. Khare et al, 18] Agrawal et al. [19]. The different fungicides were significantly superior over control and four different species of Trichoderma was identified as better antagonist for *Fol* and can be recommended for management of Fusarium wilt in lentil and organic/ commercial cultivation of lentil [20] Looking to the importance of disease present investigation was conducted in major lentil growing areas of lentil to portray the picture of lentil wilt occurrence in M. P. under changing climatic conditions.

2. MATERIALS AND METHODS

2.1 Roving Survey

A roving survey was conducted in different locations of major lentil growing areas of Madhya Pradesh, India. To document the status of lentil wilt in these areas, in total eight districts namely Jabalpur, Katni, Mandla, Dindori, Damoh, Khandwa, Sagar and Vidisha were covered to identify the disease incidence. The survey was conducted during November to February at different location and during the survey GPS coordinates comprising of latitude and longitude was also recorded along with the applied seed treatment practices before sowing. Further information was documented on the cropping pattern to identify the effect of cropping pattern on incidence of lentil wilt in these locations. The details of locations along with block and village and survey and survey period is presented in Table 1.

Wilt infected root samples were collected from infected fields of eight lentil growing districts *viz*; Jabalpur, Katni, Mandla, Dindori, Damoh, Khandwa, Sagar and Vidisha district of Madhya Pradesh during *rabi* season 2020–21 to 2021–22. In total 23 isolates were obtained with GPS locations (Latitude and Longitude) and the details of isolates and the locations from where isolation was done are given in Table 1.

Table 1. List of surveyed locations with their GPS coordinates and cropping pattern

District	Block	Village	GPS coordinates		Period of survey	Cropping pattern (Previous crop)	Seed treatment
			Latitude	Longitude			
Jabalpur	Jabalpur	[1]Jabalpur	23.210881	79.9456	Nov–Dec	Soybean	Yes
	Sihora	[2]Sihora	23.496649	80.1027	Nov–Dec	Rice	No
		[3]Uldna	23.521682	80.1344	Nov–Dec	Rice	Yes
	Patan	[4]Patan	23.316261	79.6603	Nov–Dec	Soybean	No
Katni	Bahoriband	[5]Paturia	23.638461	80.0864	Dec–Jan	Rice	Yes
		[6]Salaiya	23.738147	80.0191	Dec–Jan	Rice	No
		[7]Khamtara	23.745553	79.9827	Dec–Jan	Maize	No
		[8]Bakal	23.758299	79.9686	Dec–Jan	Rice	No
Damoh	Tendukheda	[9]Harrai	23.403761	79.527	Dec–Jan	Maize	No
		[10]Tendukheda	23.404771	79.5214	Dec–Jan	Vegetables	No
Mandla	Bijadandi	[11]Bijadandi	23.006706	80.1312	Jan–Feb	Rice	No
	Narayanganj	[12]Narayanganj	22.847442	80.2319	Jan–Feb	Rice	No
	Mandla	[13]Mandla	22.640166	80.3694	Jan–Feb	Rice	Yes
	Bichhiya	[14]Bichhiya	22.46234	80.6466	Jan–Feb	Rice	Yes
	Mawai	[15]Kolamgahan	22.559642	80.9161	Jan–Feb	Rice	Yes
		[16]Bhanpur	22.592266	80.9025	Jan–Feb	Rice	No
Dindori	Amarpur	[17]Jaitpuri	22.574857	80.9433	Jan–Feb	Finger millet	No
		[18]Kamko mohniya	22.579581	80.9563	Jan–Feb	Sorghum	No
		[19]Jalegaon	22.585868	80.965	Jan–Feb	Finger millet	No
Khandwa	Pandhana	[20]Dongargaon	21.612634	76.3811	Jan–Feb	Black gram	No
Sagar	Sagar	[21]Sagar field-1	23.796906	78.5928	Jan–Feb	Soybean	No
		[22]Sagar field -2	23.796936	78.5955	Jan–Feb	Soybean	No
Vidisha	Gyaraspur	[23]Gyaraspur	23.680682	78.1127	Jan–Feb	Maize	Yes

2.2 Disease Incidence Assessment

Disease incidence were undertaken for the current study at different districts of Madhya Pradesh. Disease Incidence was recorded from the first appearance of disease symptoms. Plants that showed complete or partial wilting were considered wilted and staked to avoid double counting in subsequent assessments. The percent of wilt incidence was calculated on the basis of the initial plant count and the total number of diseased plants in each quadrate using the following formula.

Percent disease incidence will be calculated using the following formula:

Disease incidence (%) = Number of wilted plants in quadrate / Total number of plants observed in quadrate ×100

3. RESULTS AND DISCUSSION

3.1 Status of Lentil wilt from Lentil Growing Region in Madhya Pradesh at Farmers' Field

The prevalence of lentil wilt was recorded at 23 different locations covering eight districts of Madhya Pradesh *viz*; Jabalpur, Katni, Mandla, Dindori, Damoh, Sagar, Vidisha and Khandwa during 2020–21 to 2021–22 (Table 2, Fig. 1). Surveyed villages The disease incidence was recorded on the basis of typical field symptoms from the selected region of Madhya Pradesh. Wilt incidence was calculated by using the quadrate method size (1×1 m^2) in the farmer's field. Fusarium wilt was identified on the basis of typical field symptoms and later confirmation was made through microscopic observation for associated pathogens.

Fig. 1. Survey districts of Madhya Pradesh for recording the prevalence of lentil wilt

Table 2. Details of locations surveyed in different district

District	Surveyed villages
Jabalpur	[1]Jabalpur, [2]Sihora, [3]Uldna and [4]Patan
Katni	[5]Paturia, [6]Salaiya, [7]Khamtara and [8]Bakal
Damoh	[9]Harrai and [10]Tendukheda
Mandla	[11]Bijadandi, [12]Narayanganj, [13]Mandla, [14]Bichhiya, [15]Kolamgahan and [16]Bhanpur
Dindori	[17]Jaitpuri, [18]Kamko mohniya and [19]Jalegaon
Khandwa	[20]Dongargaon
Sagar	[21]Sagar field-1 and [22]Sagar field -2
Vidisha	[23]Gyaraspur

During 2020–21, the maximum wilt incidence of 26.6% was recorded in Sagar field-1 village followed by 25.05% in Dongargaon village. However, the minimum wilt incidence of 5% was recorded in Uldna village followed by 9.88% in Jabalpur village. Further, during 2021–22, the maximum wilt incidence of 18.98% was recorded in Sagar field-2 village followed by 18.74% in Khamtara village. However, the minimum wilt incidence of 7.44% was recorded in Gyaraspur village followed by 8.23% in Uldna village (Table 3).

Table 3. Occurrence of lentil wilt at different locations of Madhya Pradesh during 2020–21 and 2021–22

District	Block	Village	Average disease incidence		
			2020–21	2021–22	Average incidence
Jabalpur	Jabalpur	[1]Jabalpur	9.88	12.64	11.26
	Sihora	[2]Sihora	20.33	14.72	17.53
		[3]Uldna	5.00	8.23	6.62
	Patan	[4]Patan	19.24	10.38	14.81
	Range		5.00–20.33	8.23–14.72	6.62–17.53
	Mean		13.61	11.49	12.55
Katni	Bahoriband	[5]Paturia	14.38	11.89	13.13
		[6]Salaiya	16.94	18.42	17.68
		[7]Khamtara	21.99	18.74	20.36
		[8]Bakal	16.18	14.18	15.18
	Range		14.38–21.99	11.89–18.74	13.13–20.36
	Mean		17.37	15.8	16.58
Damoh	Tendukheda	[9]Harrai	19.03	16.81	17.92
		[10]Tendukheda	12.21	18.60	15.40
	Range		12.21–19.03	16.81–18.60	15.40–17.92
	Mean		15.62	17.70	16.66
Mandla	Bijadandi	[11]Bijadandi	17.9	12.36	15.13
	Narayanganj	[12]Narayanganj	19.32	15.06	17.19
	Mandla	[13]Mandla	13.06	13.76	13.41
	Bichhiya	[14]Bichhiya	16.51	11.34	13.92
	Mawai	[15]Kolamgahan	11.66	13.56	12.61
		[16]Bhanpur	12.62	16.77	14.69
		Range	11.66–19.32	11.34–16.77	12.61–17.19
		Mean	15.17	13.80	12.17
Dindori	Amarpur	[17]Jaitpuri	18.52	12.41	15.46
		[18]Kamko mohniya	15.02	18.04	16.53
		[19]Jalegaon	13.15	16.12	14.64
	Range		13.15–18.52	12.41–18.04	14.64–16.53
	Mean		15.56	15.52	15.54
Khandwa	Pandhana	[20]Dongargaon	25.05	10.29	17.67
		Range	-	-	-
		Mean	25.05	10.29	17.67
Sagar	Sagar	[21]Sagar field-1	26.6	9.9	18.25
		[22]Sagar field -2	20.38	18.98	19.68
	Range		20.38–26.60	9.90–18.98	18.25–19.68
	Mean		23.49	14.44	18.96
Vidisha	Gyaraspur	[23]Gyaraspur	19.87	7.44	13.66
	Range		-	-	-
	Mean		19.87	7.44	13.66
SEm±			1.82	1.42	3.05
CD (*p*=0.05)			5.2	4.07	N/A

Based on pooled data of 2020–21 and 2021–22, among the 23 different locations maximum average wilt incidence of 20.36 % could be recorded in Khamtara village of Bahoriband block from Katni district followed by 19.68% in Sagar field-2 from Sagar district. However, least incidence of 6.62% was recorded in Uldna village from Sihora block of Jabalpur district. There was significant different in occurrence of lentil wilt across eight surveyed districts. The mean incidence of lentil wilt over a period of two years ranged from 6.62–17.53% in Jabalpur, 13.13–20.36% in Katni, 15.40–17.92% in Damoh, 12.61–17.19% in Mandla, 14.64–16.53% in Dindori and 18.25–19.68% in Sagar district. However, the district wise scenario of lentil wilt over a period of two consecutive years revealed that maximum average incidence of 18.96 % was recorded in Sagar district followed by 17.67% in Khandwa district. However, minimum average wilt incidence of 12.17% was recorded in Mandla district followed by 12.55% in Jabalpur district (Fig. 2). The average disease incidence of lentil wilt was comparatively lesser during 2021-22 than 2020-21 in all the surveyed districts except Damoh district where slightly higher incidence of lentil wilt was recorded during 2021–22 than 2020–21. Looking to the disease incidence during 2020–22, Sagar, Khandwa, Damoh, Katni and Dindori were identified as hotspot pockets for occurrence of lentil wilt in surveyed districts of Madhya Pradesh. The detailed data for lentil wilt incidence in different locations are given in Table 3.

Lentil wilt is a major limiting factor hampering the lentil production across the major lentil growing areas not only in India but other countries also. Several workers have identified the variable amount of disease across different areas which may be attributed due to several factors including presence of initial inoculum in soil, climatic and edaphic factors. Further, the role of preceding crop is also crucial in buildup and persistence of initial inoculum to initiate the lentil wilt in different areas. In the present investigation, among the eight surveyed districts, Sagar, Khandwa, Damoh, Katni and Dindori were identified as hotspot pockets for occurrence of lentil wilt. It was also studied the prevalence of lentil wilt in Pakistan covering seven districts where they reported 25.7% wilt incidence. In another study by (Dubey, 2021) variable amount of lentil wilt was reported from different areas of Northwestern Algeria. The results of present investigation are in tune to the findings of Kumari *et al.* (2020) and Chaudhary et al. (2010) where differential occurrence of lentil wilt has been portrayed from different locations.

3.2 Effect of Seed Treatment on Incidence of Lentil Wilt

Seed treatment significantly reduced the incidence of lentil wilt in the surveyed locations. The fields where farmers practiced the seed treatment before sowing of the lentil crop, the wilt incidence ranged from 6.62–13.92%. However, the fields sown without any seed treatments exhibited 14.18–20.36% wilt incidence. The overall picture across 23 surveyed locations across eight districts of Madhya Pradesh depicted the mean incidence of lentil wilt of 12.26% in field sown with seed treatment and 16.63% incidence in the field sown without any seed treatment (Table 4). The application of seed treatment practices has been reported to be a successful measure for control of seed and/or soil borne diseases [21,22]. In the present investigations also seed treatment significantly reduced the incidence of lentil wilt in surveyed locations.

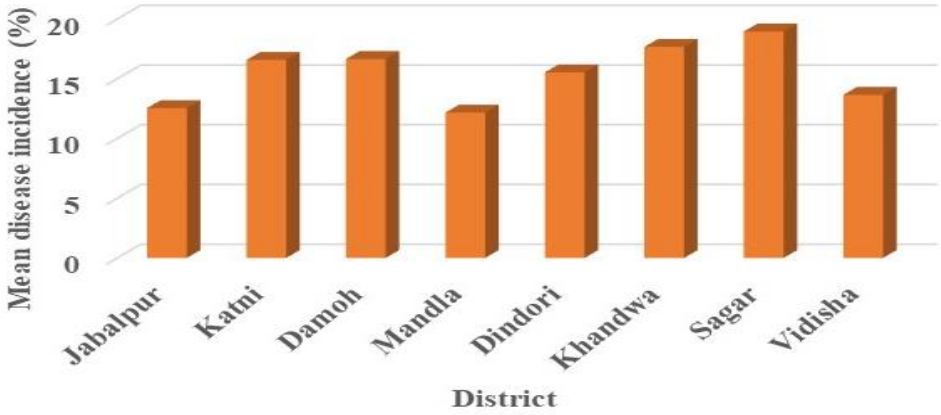

Fig. 2. District wise incidence of lentil wilt

Table 4. Effect of seed treatment on incidence of lentil wilt

District	Block	Village	Average disease incidence under seed treatment	
			Yes	No
Jabalpur	Jabalpur	[1]Jabalpur	11.26	-
	Sihora	[2]Sihora	-	17.53
		[3]Uldna	6.62	-
	Patan	[4]Patan	-	14.81
	Mean		8.94	16.17
Katni	Bahoriband	[5]Paturia	13.13	-
		[6]Salaiya	-	17.68
		[7]Khamtara	-	20.36
		[8]Bakal	-	15.18
	Mean		13.13	17.74
Damoh	Tendukheda	[9]Harrai	-	14.18
		[10]Tendukheda	-	15.4
	Mean		-	14.79
Mandla	Bijadandi	[11]Bijadandi	-	15.13
	Narayanganj	[12]Narayanganj	-	17.19
	Mandla	[13]Mandla	13.41	-
	Bichhiya	[14]Bichhiya	13.92	-
	Mawai	[15]Kolamgahan	12.61	-
		[16]Bhanpur	-	14.69
		Mean	13.31	15.56
Dindori	Amarpur	[17]Jaitpuri	-	15.46
		[18]Kamko mohniya	-	16.53
		[19]Jalegaon	-	14.64
	Mean		-	15.54
Khandwa	Pandhana	[20]Dongargaon	-	17.67
		Mean	-	17.67
Sagar	Sagar	[21]Sagar field-1	-	18.25
		[22]Sagar field -2	-	19.68
	Mean		-	18.96
Vidisha	Gyaraspur	[23]Gyaraspur	13.66	-
	Mean		13.66	-
Overall Mean			12.26	16.63

The study concluded the 26.28% reduction in wilt occurrence with the application of seed treatment before sowing. The farmers practicing the seed treatment were not aware about the actual ingredients used for seed treatment. However, most of the farmers either used locally used *Trichoderma* spp. or carboxin+thiram.

3.3 Effect of Cropping Pattern on Incidence of Lentil Wilt

Across eight surveyed districts of Madhya Pradesh, Lentil was sown as a succeeding crop after seven crops including rice, soybean, maize, finger millet, sorghum, black gram and vegetables. However, the farmers mainly practiced Rice–lentil cropping pattern followed by rice-soybean. The overall incidence of lentil wilt ranged from 13.96–21.17% in different cropping pattern. Under the seven cropping patterns observed, the highest incidence of 17.67% lentil wilt was recorded in black gram followed by lentil. This was followed by 21.17% wilt incidence in maize-lentil cropping pattern. The minimum wilt incidence of 13.96% was recorded in rice followed by lentil which is the most predominant cropping pattern across the surveyed locations (Table 5).

Madhya Pradesh, commonly referred as Soya Bowl of India, also exhibited higher incidence of lentil wilt when soybean sown before lentil in all the cropping pattern except sorghum and rice-based cropping pattern.

Table 5. Effect of cropping pattern on lentil wilt incidence

Cropping pattern (Number of fields)	Average disease incidence (%)		
	2020–21	2021–22	Mean
Soybean (04)	19.03	12.98	16.00
Rice (11)	14.90	13.66	13.96
Maize (03)	20.30	14.33	17.31
Finger millet (02)	15.84	14.27	15.05
Sorghum (01)	15.02	18.04	16.53
Black gram (01)	25.05	17.29	21.17
Vegetables (01)	12.21	18.60	15.4
CD (0.05)	0.033	0.044	N/A
SE(m)	0.009	0.013	2.59

Table 6. Varietal reaction of different varieties of lentil for wilt disease

S. No	Variety	Wilt incidence (%) 2020-21	Wilt incidence (%) 2021-22	Average wilt incidence (%)
1.	L 4727	3.53	3.47	3.50
2.	RVL 31	4.93	5.07	5.00
3.	IPL 316	9.97	11.03	10.50
4.	Shekhar masoor 3	13.35	15.65	14.50
5.	PL 5	15.56	15.44	15.50
6.	PL 8	5.26	4.74	5.00
7.	DPL 62	2.60	2.40	2.50
8.	JL 1	0.00	0.00	0.00
9.	JL 3	2.47	2.53	2.50
10.	IPL 81	5.22	5.78	5.50
11.	Kota 1	3.22	3.78	3.50
12.	Kota 2	5.52	5.48	5.50
13.	RKL 14-20	2.63	2.37	2.50
14.	L 4076	0.00	0.00	0.00
	SEm±			0.49
	CD (*p*=0.05)			1.53

3.4 Varietal Screening for Lentil Wilt

In total 14 varieties of lentil were screened for occurrence of lentil wilt at Sagar during 2019-20. Among the different varieties evaluated, maximum incidence of lentil wilt was recorded in PL 5 (15.5%) followed by 14.5% in Shekhar masoor 3. However, two varieties namely JL 1 and L 4076 were found free from wilt incidence and showed resistant reaction for lentil wilt (Table 6). Looking to the reaction of these two varieties, these can be incorporated in conventional/molecular breeding platform for incorporating wilt resistance in elite lentil varieties. So far, many workers have investigated the wilt reaction of different lentil germplasm/lines/varieties at different locations. (Arya and Kushwaha, [23] Kharte et al, [24] investigated a set of ninety-two germplasms of lentil for wilt reaction and observed 05 groups comprising of eleven varieties showing highly resistance towards lentil wilt [25,26].

4. CONCLUSION

Out of the twenty-three locations, Uldna (6.62%) had the lowest frequency of lentil wilt, whereas village-7 Khamtara had the greatest. In 7 apparent cropping patterns, rice had the lowest wilt incidence (13.96%). The findings include identifying hotspot lentil wilt pockets in central India, as well as for multi-locational testing of lentil genotypes for wilt reaction and subsequent implementation of management practices. Also, two varieties, JL 1 and L 4076, were wilt resistant, acts as genetic resource for varietal development.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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