

**IDENTIFICATION OF BANDED LEAF AND SHEATH BLIGHT RESISTANCE IN FINGER MILLET
(*ELEUSINE CORACANA* L. GAERTN.) GENOTYPES AGAINST *RHIZOCTONIA SOLANI* KUHN**

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ABSTRACT: Banded leaf and sheath blight (BLSB) of finger millet is an emerging disease and may cause substantial yield losses under favorable environmental conditions. In the present study, twenty-six genotypes of finger millet were screened against BLSB under artificial inoculations. A significant variation in number of lesions, length of lesions and relative lesion height (RLH) was recorded in all the screened finger millet genotypes. Number of lesions varied from 4.3 to 11.4 with a mean of 8.3, lesion length varied from 3.9 to 11.7 cm with a mean of 8.7 cm, RLH from 15.4 to 47.1% with a mean of 35.6% were recorded. Incubation period varied from 2.2 to 5.4 days with a mean of 3.2 days; apparent infection rate varied from 0.009 to 0.056 with a mean of 0.020 percent per day and the values of AUDPC varied from 102.8 to 261.2 with a mean of 195.9 were recorded. Two genotypes of finger millet KMR 650 and GPU 99 were found resistant to BLSB showing less number and length of lesions, less than 20% RLH, lower apparent infection rate and AUDPC values with higher incubation period. RAUF 17 was found moderately resistant and three genotypes namely TNEc 1299, REC 69, Uduru Mallige were found susceptible to BLSB under artificial inoculations. Correlation coefficients study revealed that lesion number, lesion length, relative lesion height, incubation period, apparent infection rate and AUDPC contributed to progression of BLSB severity.

Key words: Finger millet, banded leaf and sheath blight, severity, resistance, correlations

Finger millet (*Eleusine coracana* L. Gaertn), commonly known as *ragi*, is a widely cultivated small millet crop of Asia and Africa. The crop is grown by resource poor farmers in low fertile soils. In India, the crop is cultivated over an area of 0.988 m ha with a production of 1.587 m. tons and productivity of 1607 kg/ha (Tonapi, 2020). Banded leaf and sheath blight (BLSB) caused by *Rhizoctonia solani* Kuhn is an emerging disease of finger millet that occurs at all stages of plant growth and may cause substantial yield losses under favorable environmental conditions. In India, the disease was first reported from Vellayani in Kerala in a severe form by Das and Girija (1989). Later, the disease was also reported from Bihar (Dubey, 1995), Uttarakhand (Kumar, 2010) and Karnataka (Nagaraja and Anjaneya Reddy, 2010). Now, the disease is prevalent in all the finger millet growing areas of the country (Nagaraja *et al*, 2016). A description of the symptoms of disease on finger millet was given, and pathogen was identified as *Rhizoctonia solani* AG-I (Dubey, 1995). Nagaraja and Reddy (2010) observed oval to irregular, light to dark brown lesion on the lower leaf sheath of finger millet. Later, central portions of lesions turned white to straw with narrow reddish-brown borders. Spots were also observed on leaf blades under favorable conditions. The lesions enlarged rapidly and coalesced to cover large portions of the sheath and leaf lamina. Nagaraja *et al* (2016) reported that temperature range from 23-30°C and a relative humidity of 80% or above favors rapid disease development. They also reported mycelia growth along with white to brown sclerotia around the lesions.

Later, the leaves dry up and plants appear blighted. Use of host plant resistance is the most economical and feasible way for the management of any soil borne disease. In finger millet very few studies were undertaken to find out the resistant sources against BLSB (Patro *et al*, 2020). Seed treatment with propiconazole 1 ml kg⁻¹ and hexaconazole 2 ml kg⁻¹ seed were found most effective in reducing the banded blight in finger millet (Patro and Madhuri, 2014). Foxtail millet, finger millet, proso millet and little millet isolates of *Rhizoctonia solani* were found cross infective with each other. Slow growing isolates of foxtail millet, finger millet and little millet were more aggressive than medium and fast-growing isolates (Krishnaveni *et al*, 2020). In the present study, attempts have been made to identify resistant sources of finger millet against BLSB and disease variables responsible for disease development.

MATERIALS AND METHODS

The diseased leaf sheaths collected from previous crop season showing characteristic symptoms were thoroughly washed repeatedly in tape water. Thereafter, small bits measuring about 5 mm were cut for isolation. The sheath bits were surface sterilized with 0.1 per cent mercuric chloride (HgCl₂) solution for 30 seconds followed by three changes of sterilized water. The surface sterilized sheath bits were aseptically transferred to the petri plates containing potato dextrose agar (PDA) medium and incubated at 28±2° C. After 48 hours of incubation, the growing mycelium from the margin of apparently distinct colonies were subculture aseptically

on fresh PDA plates and pure culture of *R. solani* was maintained. Temporary slides of the culture were prepared in lacto phenol cotton blue and examined under compound microscope for the mycelia characters for confirmation and identification of the fungus.

The seeds of twenty-six finger millet genotypes were sown in 10 rows with 22.5 cm row to row and 10.0 cm plant to plant spacing in randomized block design with three replications at experimental area of AICRP on Small Millets, College of Agriculture, Rewa (M.P.) during *Kharif* 2018. Recommended doses of fertilizers i.e. 50 kg N and 40 kg P₂O₅ per hectare and package of practices were adopted for optimum plant growth. Ten

plants of each genotype from each replication were tagged and artificially inoculated with fresh sclerotia of *Rhizoctonia solani* at 40 days after sowing. Sclerotia were inserted between the stem of the middle tiller of each plant and leaf sheath of basal node. High humidity was maintained during disease development by frequent watering. The inoculated plants were observed daily for development of symptoms. Observations on number of lesions (LN), lesion length (cm) and vertical disease spread in terms of relative lesion height (RLH) were recorded at 10 days interval in each genotype till 70 DAS. The RLH (%) was calculated as per formula given by Ahn *et al* (1986).

$$\text{RLH (\%)} = \frac{\text{Total lesion length}}{\text{Total length of sheath}} \times 100$$

The incubation period (days) was recorded from time of inoculation to the appearance of the disease symptoms in all the screened finger millet genotypes. Apparent infection rate (r) was calculated using relative lesion height adopting the formula given by Van der Plank (1963).

$$r = \frac{1}{t_2 - t_1} \frac{X_2}{\text{Log}_e X_1}$$

Where,

r is the apparent infection rate per day

t₁ and t₂ is the initial and final time for disease recorded

X₁ and X₂ are the proportions of lesion height at time t₁ and t₂, respectively.

Area under Disease Progress Curve (AUDPC) was calculated using a simple midpoint formula as described by Madden *et al* (2007).

$$\text{Where, } \text{AUDPC} = \sum_{i=1}^{n-1} \left(\frac{y_i + y_{i+1}}{2} \right) (t_{i+1} - t_i)$$

“n” is the number of observations.

The screened genotypes were grouped into different categories of reaction according to Standard Evaluation Scale (SES).

SES (0-9) for banded leaf and sheath blight of Finger millet

Scale	Description	Host reaction
0	No infection	Highly resistant (HR)
1	Vertical spread of the lesions up to 20% of plant height.	Resistant (R)
3	Vertical spread of the lesions up to 21-30% of plant height.	Moderately resistant (MR)
5	Vertical spread of the lesions up to 31-45% of plant height.	Moderately susceptible (MS)
7	Vertical spread of the lesions up to 46-65% of plant height.	Susceptible (S)
9	Vertical spread of the lesions is more than 65% of plant height.	Highly susceptible (HS)

The values expressed in percentage were transformed to angular (arc-sin) values before analysis. The data were analyzed statistically using Randomized Block Design. Correlation coefficients were calculated using computer software WASP-I.

RESULTS AND DISCUSSION

Significant differences in number of lesions, lesion length (cm) and relative lesion height (RLH) were recorded in 26 entries of finger millet at 70 days after

sowing (Table 1). Days to 50% flowering ranging from 58 to 105 days with a mean of 84 days was minimum in Uduru Mallige followed by REC 69 (59 days) and maximum in GSMS 1 and WN 568 followed by GPU 99 (103 days). Mean number of lesions ranging from 4.3 to 11.4 with an average of 8.3 were recorded. Lowest number of lesions were recorded in IIMRFM-8023-17 (4.3) followed by GSMC-1 (4.7), PR 202 (5.1), KMR 650 and GPU 99 (5.7). Whereas highest number of sions

were recorded in WN 562 (11.4) followed by VL 394 (11.1), VR 1110 (10.7) and TNEc 1299 (10.3). Average lesion length ranging from 3.9 to 11.7 cm with a mean of 8.7 cm was recorded. Lowest lesion length was recorded in GPU 45 (3.9 cm) followed by IIMRFM-8023-17 (5.2 cm), HR-13 (5.7 cm) and GPU 98 (6.7 cm), while highest lesion length was recorded in BR-14-27 (11.7 cm) followed by VL 394 (11.6 cm), VR 1117 (11.3 cm), KMR 652 and PR 1639 (10.9 cm). The values of RLH ranged from 15.4 to 47.1% with a mean of 35.6% were recorded at 70 days after sowing (DAS). Lowest value was recorded in KMR 650 followed by GPU 99 (16.7%) and highest in Uduro Mallige followed by REC 69 (46.7%) and TNEc 1299 (46.3%).

Incubation period, apparent infection rate (r) and area under disease progress curve (AUDPC) were calculated in 26 genotypes of finger millet and data are presented in Table 2. Incubation period ranging from 2.2 to 4.5 days was recorded in finger millet genotypes. The lowest incubation period was recorded in Uduro Mallige followed by REC 69 (2.3 days), TNEc 1299 (2.4 days), TNEc 1297 (2.5 days) and HR 13 (2.9 days), whereas highest incubation period was recorded in KMR 650 (4.5 days) followed by GPU 99 (4.3 days) and RAUF 17 (4.1 days). In rest of the genotypes, it varied from 3.0 to 3.8 days. The mean apparent infection rate was 0.015 between 40 to 50 DAS, 0.029 between 50 to 60 DAS and 0.017 between 60 to 70 DAS with an average of 0.020 percent per day. Apparent infection rate was minimum between 40 to 50 DAS (0.015) indicates the less favorable conditions for disease development. Highest value of apparent infection rate (0.029) was found between 50 to 60 DAS indicates the favorable period for disease development. Average apparent infection rate of consecutive observation period was ranged from 0.009 to 0.056 percent per day in 26 genotypes of finger millet. Lowest apparent infection was recorded in KMR 650 (0.008) followed by VL 394 (0.012), OEB 604 (0.013), WN 562 and IIMRFM 8011-17 (0.014), Whereas highest values were recorded in GPU 45 (0.056) followed by HR 13 (0.031) and IIMRFM 8023-17 (0.028). It measures the severity strength of the linear relationship between two variables. The value of AUDPC varied from 102.8 to 261.2 with a mean of 195.9 was found in different finger millet genotypes. Minimum values were found in GPU 99 (102.8) followed by KMR 650 (134.7). Whereas maximum values were recorded in Uduro Mallige (261.2) followed by REC 69 (253.2) and TNEc 1299 (250.5).

Based on the vertical spread of the disease in terms of RLH (%), 26 genotypes of finger millet were grouped into different categories of resistance/ susceptibility (Table 3). None of the evaluated genotypes were highly resistant to BLSB. However, two genotypes, namely KMR 650 and GPU 99 were found resistant against BLSB. RAUF 17 was found moderately resistant and 20 entries namely WN 591, WN 562, VL 394, VL 382, KMR 652, OEB 604, HR 13, VR 1110, VR 1117, BR 14-27, PR 1639, GPU 98, TNEc 1297, IIMRFM 8023-17, IIMRFM 8011-17, GSMC 1, GPU 67, GPU 45, VL

376, PR 202 were moderately susceptible. Three genotypes, namely TNEc 1299, REC 69, Uduro Mallige were found susceptible to BLSB showing more than 45% vertical spread of the disease. Maximum percentage of banded blight was also recorded in finger millet genotype Uduro mallige (98.4%) by Patro *et al* (2020).

Correlation coefficients (r) were calculated among the BLSB related parameters (Table 4). Significant positive correlations between lesion number and lesion length (0.709*), lesion number and relative lesion height (0.413*), lesion length and relative lesion height (0.397*), relative lesion height and apparent infection rate (0.448*), incubation period and apparent infection rate (0.862*), incubation period and AUDPC (0.658*) were recorded. Whereas significant negative correlations between RLH and IP (-0.499*), RLH and AUDPC (-0.510*) and IR and AUDPC (-0.815*) were recorded. Other correlations were found either positive or negative but non-significant. Similar results were also reported by Goth and Nowick (1992), who found higher correlation between lesion type and disease reaction. Lesion type was the best and easiest selection criteria for identification of resistance against rice sheath blight. Willocquet *et al* (2011) reported that number of lesions, maximum lesion length and vertical sheath colonization were main components of resistance measured with respect of physiological resistance to rice sheath blight. Hossain *et al* (2014) also observed significant correlations among diseased plant affected area, visual rating (VRT) and relative lesion height with VRT being the most accurate in rice against *R. solani*. Kahar (2017) in kodo millet and Kumar (2018) in little millet were also reported that low values of apparent infection rate as well as AUDPC and higher incubation period contributed towards resistance and for identification of slow blighting genotypes against *R. solani* causing banded leaf and sheath blight disease.

It may be concluded that two genotypes of finger millet namely KMR 650 and GPU 99 were resistant to banded leaf and sheath blight (BLSB). Less number of lesions, low lesion length, less than 20% RLH, higher incubation period, lower apparent infection rate and AUDPC values were recorded in these genotypes. These disease variables significantly contributed in resistance. Finger millet genotype RAUF 17 was found moderately resistant and three genotypes namely TNEc 1299, REC 69 and Uduro Mallige were found susceptible to BLSB with higher number of lesions, lesion length, RLH, higher apparent infection rate, higher values of AUDPC and lower incubation period.

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Table-1: Performance of finger millet genotypes against *Rhizoctonia solani* causing banded leaf and sheath blight disease.

S. No.	Entry	Days to 50% flowering	No. of lesions	Lesion length (cm)	RLH (%)	Reaction
1	WN 591	88	9.1	9.1	34.7(36.07)	MS
2	WN 562	105	11.4	9.9	37.1(37.52)	MS
3	VL 394	75	11.1	11.6	34.4(35.91)	MS
4	VL 382	69	9.3	9.3	31.7(34.24)	MS
5	KMR 650	85	5.7	5.7	15.4(23.07)	R
6	KMR 652	100	10.0	7.9	38.3(38.23)	MS
7	OEB 604	88	9.4	9.3	33.3(35.19)	MS
8	HR-13	83	11.3	9.9	39.7(39.02)	MS
9	VR 1110	88	10.7	10.7	35.5(36.56)	MS
10	VR1117	85	10.1	11.3	31.6(34.17)	MS
11	BR-14-27	84	8.4	11.7	38.6(38.40)	MS
12	PR 1639	87	9.7	10.9	39.9(39.13)	MS
13	GPU 98	87	7.3	6.7	33.1(35.10)	MS
14	GPU 99	103	5.7	5.2	16.7(24.07)	R
15	RAUF 17	86	6.6	9.1	29.3(32.67)	MR
16	TNEc 1297	85	9.1	7.4	44.4(41.77)	MS
17	TNEc 1299	90	10.3	10.2	46.3(42.86)	S
18	IIMRFM-8023-17	74	4.3	7.7	31.5(34.13)	MS
19	IIMRFM-8011-17	66	8.3	9.8	33.9(35.59)	MS
20	GSMC-1	105	4.7	6.3	36.7(37.27)	MS
21	GPU 67	95	6.9	6.8	38.8(38.53)	MS
22	GPU 45	85	7.2	3.9	39.6(38.96)	MS
23	VL 376	63	6.7	7.1	37.5(37.73)	MS
24	PR 202	86	5.1	6.6	34.4(35.90)	MS
25	REC 69	59	8.3	10.9	46.7(43.10)	S
26	Uduru Mallige	58	8.9	10.7	47.1(43.32)	S
	Mean	84	8.3	8.7	35.6	
	CD (5%)		0.828	4.387	3.779	

Figures in parentheses are ARC SIN transformed values

R=Resistant, MR= Moderately resistant, MS= Moderately susceptible, S=Susceptible

Table-2: Incubation period, apparent infection rate and area under disease progress curve (AUDPC) in 26 genotypes of finger millet.

S. No.	Entry	Incubation period (days)	Apparent infection rate (r)				AUDPC
			40-50 DAS	50-60 DAS	60-70 DAS	Mean	
1	WN 591	3.0	0.015	0.016	0.017	0.016	206.5
2	WN 562	3.1	0.008	0.020	0.013	0.014	233.0
3	VL 394	3.0	0.005	0.017	0.014	0.012	217.5
4	VL 382	3.4	0.009	0.011	0.026	0.015	172.2
5	KMR 650	4.5	0.014	0.007	0.005	0.007	134.7
6	KMR 652	3.2	0.006	0.023	0.019	0.016	212.3
7	OEB 604	3.3	0.006	0.022	0.011	0.013	212.2
8	HR-13	2.9	0.055	0.025	0.012	0.031	227.8
9	VR 1110	3.0	0.011	0.024	0.014	0.016	211.3
10	VR1117	3.7	0.013	0.018	0.016	0.016	189.5
11	BR-14-27	3.1	0.004	0.027	0.015	0.015	221.8
12	PR 1639	3.1	0.007	0.034	0.012	0.018	230.2
13	GPU 98	3.3	0.018	0.026	0.029	0.024	150.7
14	GPU 99	4.3	0.029	0.008	0.017	0.018	102.8
15	RAUF 17	4.1	0.015	0.022	0.018	0.018	164.3
16	TNEc 1297	2.5	0.010	0.040	0.025	0.025	199.3
17	TNEc 1299	2.4	0.005	0.016	0.024	0.015	250.5
18	IIMRFM-8023-17	3.8	0.012	0.044	0.014	0.023	154.0
19	IIMRFM-8011-17	3.7	0.004	0.024	0.015	0.014	202.2
20	GSMC-1	3.5	0.014	0.050	0.012	0.025	192.0
21	GPU 67	3.4	0.021	0.056	0.012	0.030	195.0
22	GPU 45	3.1	0.008	0.040	0.012	0.020	157.0
23	VL 376	3.2	0.007	0.028	0.033	0.023	163.3
24	PR 202	3.2	0.019	0.049	0.016	0.028	178.5
25	REC 69	2.3	0.008	0.051	0.010	0.023	253.2
26	Uduru Mallige	2.2	0.075	0.068	0.024	0.056	261.2
	Mean	3.2	0.015	0.029	0.017	0.020	195.9

Table-3: Grouping of finger millet genotypes against banded leaf and sheath blight disease

Reaction	BLSB severity (RLH %)	No. of entries	Genotypes
Highly resistant	0	0	Nil
Resistant	Up to 20	2	KMR 650, GPU 99
Moderately resistant	20 – 30	1	RAUF 17
Moderately susceptible	31 – 45	20	WN 591, WN 562, VL 394, VL 382, KMR 652, OEB 604, HR 13, VR 1110, VR 1117, BR 14-27, PR 1639, GPU 98, TNEc 1297, IIMRFM 8023-17, IIMRFM 8011-17, GSMC 1, GPU 67, GPU 45, VL 376, PR 202
Susceptible	46 – 65	3	TNEc 1299, REC 69, Uduru Mallige
Highly susceptible	Above 65	Nil	-

Table- 4: Correlation coefficients among disease contributing parameters in finger millet.

-	LN	LL	RLH	IP	AIR	AUDPC
LN	1.000	0.709*	0.413*	-0.039	0.044	-0.143
LL		1.000	0.397*	-0.254	0.287	-0.327
RLH			1.000	-0.499*	0.448*	-0.510*
IP				1.000	-0.862*	0.658*
AIR					1.000	-0.815*
AUDPC						1.000

*Significant at 5%, LN= Number of lesions, LL=Lesion length, RLH= Relative lesion height, IP=Incubation period, AIR= Apparent infection rate, AUDPC= Area under disease progress curve.

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