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Screening for Identification of Resistant Genotypes against Charcoal Rot Caused by *Macrophomina phaseolina* in Maize (*Zea mays* L.)

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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

Screening of Maize entries for resistance to charcoal rot disease using 1-9 disease severity measuring scale in sick plot at field conditions. In this study,492entries with check were screened in randomized block design by tooth pick method of inoculation at Agricultural Research Station, Karimnagar, Telangana State, India during rabi and kharif. During rabi 2021-22, out of screened 212 lines,46 lines viz., KML-2, JCY-2-7, KML-4,KML-17,KML- 26,KML-33,KML-74,KML-76,KML-82,KNMH-4211,KNMH-4192,KNMH-131,KMH-396,KMH-393,KMH-770,KMH-286,KMH-275,KMH-

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318,S-6668,KMH-253,KMH-262,KMH-777,KMH-433,KMH-431,KMH-25,KMH-340,KMH-341,KMH-331,KMH-337,KMH-471,KMH-469,KMH-586,KMH-357,KMH-367,KMH-542,KMH-544,KMH543, KMH -131,KMH-394,KMH-400,KMH-545,KMH-194,DHM-121,BIO-9544,HT5106 and NK6802 were found moderately resistant, Kaveri-50 (Check) entry was recorded 8.10 disease scale and remaining lines were found susceptible to charcoal rot disease. Out of screened 280 lines,one line KMH-152 was found resistant ,77 lines were identified as moderately resistant,one line Kaveri -50 (check) was severely affected by Charcoal rot with 8.0disease rating and rated as susceptible during kharif, 2022.

Keywords: Screening; genotypes; hybrids; tooth pick method of inoculation; disease rating scale; charcoal rotdisease; Maize.

1. INTRODUCTION

Maize (*Zea mays* L.2n = 20) is known as Miracle crop and Queen of cereals. “In India, Maize is grown in an area of 10.04 million hectares with a production of 333.62 million tonnes and productivity of 3,349kg/ha. In Telangana state, maize occupies an area of 0.41 million hectares with a production of 2.13 million tons and productivity of 5,178 Kg/ha” [1]. Out of which,0.012 million hectares was the Maize area in Karimnagar (erstwhile) district.

In India, yield lag is one of the major constraints that hinder maize production. Apart from Insects and diseases, fungal diseases like post flowering stalk rots (PFSR) poses a major threat to the productivity of maize [2]. PFSR is a complex disease of maize,which commonly appears when there is scarcity of irrigation coupled with high soil temperatureat flowering stage of the crop.PFSR is caused by different fungal pathogens but Charcoal rot by *Macrophomina phaseolina* is more prevalent and destructive in Telangana State as well as in Rajasthan, Bihar, Andhra Pradesh, UttarPradesh, Punjab,Madhya Pradesh and West Bengal. The disease incidence, recorded in India time to time, ranged from 10.0 to 42.0% [3], 13.2 to 39.5% [4], 25.0 to 32.0% [5], 10.0to42.0% [6], 42 to 100% (Laxmi Sravya *et al.,*[7] and in recent years yield reduction has been reported to be as high as 22.3to 63.5% [8].

In order to combat this problem, development of maize cultivars with genetic resistant represent one of the most cost-efficient, safe and eco-friendly solutions for reducing the yield losses caused by PFSR (Charcoal rot and Fusarium rot) compared to chemical and biological control methods [9]. Information on the nature of inheritance of PFSR resistance is lacking,which is a prerequisite to initiate appropriate breeding program for the development of PFSR resistant hybrids,on which very little emphasis had been made so far. To develop disease resistant hybrids, screening of available genotypes against the pathogens was done under artificial epiphytotic condition and it yielded a set of stalkrot resistant germplasm in India [10] Hooda *et al.,* [10] and abroad [11]. In India, artificial epiphytotic condition for stalkrot disease is created by inoculating the plants in the field just after flowering mainly by toothpick method of inoculation [12].

2. MATERIALS AND METHODS

492(genotypes ,hybrids and check) entries were evaluated by raising the crop in charcoal rot disease sick plot accompanied by tooth pick inoculation during rabi 2021-2022 (November,2021 to Febrauary,2022))and kharif (July,2022 to October,2022) at Agricultural Research Station, Karimnagar,Telangana state,India.

2.1 Layout of Maize Trial for Field Screening

For the identification of source of resistance to charcoal rot disease, a set of four hundred and ninety two maize entries were evaluated in a randomized block design (RBD) along with a check (Kaveri-50) at Agricultural Research Station, Karimnagar field conditions using 1 to 9 disease rating scale [13]. The test genotypes were planted in 2 rows of 3m length each with a plant spacing of 60×20 suare centimeters.

Screening reinforced with artificial inoculation using tooth pick method is effective in

Table 1. Disease rating scale for scoring disease severity of charcoal rot disease

Disease rating Scale	Disease severity percentage (%)	Disease reaction
1	Healthy or trace/slight discolouration at the site of inoculation	Resistant (Score:≤3.0)
2	Up to 50% of the inoculated internode is discoloured	
3	51-75% of the inoculated internode is discoloured	
4	76-100% of the inoculated resistant internode is discoloured	Moderately resistant (Score:3.15.0)
5	Less than 50% discolouration of the adjacent internode	
6	More than 50% discolouration of the adjacent internode	Moderately susceptible(Score:5.17.0)
7	Discolouration of three internodes	
8	Discolouration of four internodes	Susceptible(Score:≥7.0)
9	Discolouration of five or more internodes and premature death of plant	

supplementing the disease sickplot technique of screening against charcoal rot. The tooth pick inoculation method followed is suitable for screening against a multi- pathogen disease complex [14]. Charcoal rot of maize occurs in both the growing seasons viz., kharif (rainy) and rabi (winter) at Agricultural Research station, Karimnagar. A disease sick plot was developed by incorporating infected stubbles of charcoal rot disease.

2.2 Inoculation

Inoculation of the plants of 45-50 days old was done just after flowering by tooth pick method (Anon.2012 and Hooda *et al.*, 2018.Before inoculation, one jabber was made by driving / fixing a nail of tooth pick size into a wooden handle. For inoculation, most appropriate plant stage for inoculation is between tasseling and pollination for that the lower internode (second or third) above soil level was selected. Then the pointed head of the nail was pushed carefully into the selected internode to make a hole of desired length (2cm). The round toothpick bearing inoculums were inserted into the hole that effectively sealed the hole to prevent drying of the inoculums.

Disease reaction was recorded by using 1 to 9 scale at harvesting stage and assessed the disease severity of charcoal rot disease.

Classification for the reactions for the pathogens was done on an individual plant basis, splitting the stalk open and observing the rot is the most reliable method of determining the amount and extent of stalk rot and the 1-9 scale, suggested by Payak and Sharma [15] and Hooda et al ., [13] was followed for scoring and scale has been unequally distributed into four categories of disease severity (Table1),viz., Resistant (R), Moderately Resistant (MR),Moderately Susceptible (MS) and Susceptible(S) reaction. Randomized block design method was used for analysis.

All data on the disease severity generated from the experiments conducted in field was assessed at the end.

3. RESULTS AND DISCUSSION

Maize entries were artificially inoculated by Tooth pick inoculation method under field conditions during rabi 2021-2022 and kharif 2022 to charcoal rot disease. The performance of 492 entries along with susceptible check on the basis of disease reaction on 1-9 disease scale was classified into four groups viz., Resistant (R), Moderately Resistant (MR), Moderately Susceptible (MS) and Susceptible(S) (Tables 2 and 3).

3.1 Disease Reaction during Rabi 2021-2022 Screening of Maize Genotypes in field

Out of the 50 lines screened against *M. phaseolina*, nine lines viz., KML-2, JCY-2-7, KML-4, KML-17, KML-26, KML-33, KML-74, KML-76 and KML-82 were found moderately resistant, 36 linesviz., KML-1, KML-6,KML-7, KML-8, KML-9, KML- 10, KML-11, KML-13, KML-14, KML-15, KML-21, KML-22, KML-24, KML-28, KML-29, KML-31, KML-32, KML-70, KML-71, KML-75, KML-77, KML-78, KML-79, KML-80, KML-81, KML-83, KML-86, KML-18, KML-19, KML-30, KML-66, KML-67, KML-225, PFSR-3, KML-69 and KML-16 were moderately susceptible and the remaining lines were found susceptible in rabi 2021-2022 (Table 2).

Among the 161 hybrids,one hybrid KMH-152 was found resistant,37 hybrids, viz., KNMH-4211, KNMH-4192, KNMH-131, KMH-396, KMH-393, KMH-770, KMH-286, KMH-275, KMH-318, S-6668, KMH-253, KMH-262, KMH-777, KMH-433, KMH-431, KMH-25, KMH-340, KMH-341, KMH-331, KMH337, KMH-471, KMH-469, KMH-586, KMH-357, KMH-367, KMH-542, KMH-544, KMH-543, KMH-131, KMH-394, KMH-400, KMH-545, KMH-194, DHM-121, BIO-9544, HT5106 and NK6802 were moderately resistant,110 hybrids were found moderately susceptible and 14 hybrids were found susceptible to charcoal rot disease during rabi 2021-2022 (Table 2).

3.2 Disease Reaction during Kharif-2022 Screening of maize genotypes in Field

Out of the 80 lines screened against *M. phaseolina*, only 25 lines, viz., KML-5, KML- 6, KML-7, KML-8, KML-14, KML-19, KML-20, KML-21, KML-31, KML-34, KML-36, KML-41, KML-43, KML-45, KML-46, KML-47, KML-52, KML-55, KML-63, KML-64, KML-73, KML-74, KML-77, KML-78 and KML-81 were moderately resistant, 55 lines, viz., KML-1, KML-2, KML-4, KML-9, KML-10, KML-11, KML-12, KML-13, KML-15, KML-16, KML-17, KML-22, KML-24, KML-25, KML-26, KML-27, KML-28, KML-29, KML-30, KML-32, KML-33, KML-37, KML-44, KML-48, KML-49, KML-50, KML-51, KML-53, KML-54, KML-56, KML-57, KML-58, KML-59, KML-60, KML-61, KML-62, KML-65, KML-66, KML-67, KML-69, KML-70, KML-71, KML-72, KML-75, KML-76, KML-79, KML-80, KML-82, KML-83, KML-85, KML-86, KML-87, KML-88, KML-225 and PFSR-3 were found moderately susceptible and no germplasms were found resistant to charcoal rot disease in kharif-2022 (Table 3).

Among the 200 hybrids, one hybrid KMH-152 was found resistant, 52 hybrids viz.,KMH-881, KMH-918, KMH-26, KMH-921, KMH-915, KMH-169, KMH-22, KMH-91, KMH-846, KMH-103, KMH-813, KMH816, KMH-812, KMH-907, KMH-804, KMH-58, KMH-55, KMH-902, KMH-809, KMH-799, KMH-67, KMH854, KMH-862, KMH-800, KMH-56, KMH-798, KMH-808, KMH-802, KMH-901, KMH-905, KMH-815, KMH-76, KMH-783, KMH-863, KMH-866, KMH-57, KMH-795, KMH-793, KMH-747, KMH-758, KMH-730, S-6668, DKC-9173, Kaveri ekka, IQ-8319, IQ-8220, 8227-C, NMH-007, NMH-1258, KNMH-4191, CM-202 and B-8135 were found moderately resistant, 133 hybrids were found moderately susceptible and 14 hybrids were found susceptible during kharif-2022 (Table 3).

3.3 Similar Results were reported by Scientists

Three resistant lines, namely PFSR-13-5, JCY2-2-4-1-1-1-1 and JCY3-7-1-2-1-b-1were identified to resistant PFSR (*Cephalosporium maydis*, *Fusarium moniliforme* and *Macrophomina phaseolina* (Shekhar *et al.,*2010).

Out of 34 maize genotypes screened against *M. phaseolina*, only four lines, viz. H37, E618, 18527 and 18758 were found resistant, 10 lines viz., H 62, 14933, H 109, P 503, P 408, E 684, P 364, E 613, P 345, 18855 were moderately resistant in field [16].

Out of 30 genotypes,six namely Rampur composit,Arun 2,Rampur 34,RamS03F08, TLBRS07F16 and Rampur 24 were found resistant against stalk rot complex with high yield at Rampur Chitwan in Nepal (Subash Subedi *et al.*,2016).

A set of 200 elite maize lines was screened against PFSR diseases at 9 different geographical locations of the country. Out of them 121 (‘Insec 2(k4)’ ‘Insec (K4)’, ‘NSS2W9301A(sh2sh2)’, ‘951-7’,‘Sweet corn ‘Insec 1(k4)’, ‘NC 392’, ‘DMSC 1’, ‘DMSC 36’, ‘DMSC-37-3’, ‘Gen 1858’, ‘HKI PC 4B’, ‘HKI-PC5-1’, ‘HKI-PC-5-2’, ‘HKI-PC-7’,‘HKIPC8’, ‘HKIPC -8-2’, ‘HKI-PC-8-2-1’, ‘WINPOP-1’,‘ WINPOP2’, ‘WINPOP-3’, ‘WINPOP-21’, ‘WINPOP

-21', 'WINPOP-43-1','HKI-2-6-2-4(1-2)-4', 'HKI 226','HKI 1040-5', 'HKI 1094-11-7', 'HKI 1040-5', 'HKI 1094-WG', 'CML 451(P2)', 'ESM-11-3','PFSR/ 51016-1', 'Gen 6033','Hyd05r/2-1',Hyd05R/13- 2', 'Hyd05204-1', 'LM 5', 'LM 6', 'LM 11', 'LM 12', 'LM 15', 'LM15', 'LM 16', 'V341-1', 'V351-1', 'V 351-2', 'CM114', 'CM123', 'CM132', 'CM144', 'CM 149', 'CM 500', 'HKIC 78', 'HKI 141-1', 'HKI 141-2', ' HKIC 323', 'HKI1352-5-8-9', 'CML141', 'CML 269' , 'CML 384', 'HKI 16-4-(1-3)-2', 'HKI 164-7-4 ER-3', 'HKI 164-7-4', 'HKI 164-7-4-2', 'HKI164-7-2', 'HKI 193-2-2', 'HKI 193 2-2-1', 'HKI 193-2-2-4', 'HKI 193-1', 'CML 165', 'CML 167', 'CML 171', 'CML 172','HKI MBR-139','HKIMBR-1392', 'DMR QPM-03-104' ,'DMR QPM-58-26','CML158', 'CL-QR CYQ47', 'CLQR CYQ-47-B' , 'CLQ-RCYQ30', 'CLQ- RCYQ36', 'CLQ-RCYQ40', 'CML451Q', 'DMRQPM58', 'HKI3322', 'DMHOC 4', 'Temp. Hoc15', 'Tem. Trop High oil QPM', 'PFSR-R2', 'PFSR-R3', 'PFSR-R9', 'PFSR-R10', 'PFSR-S2', 'PFSR-S3', 'SW-930-313-23-OQ-49-54-1-3-1-1-1-2-1-2-1-2-31-1-2', JCY2-1-2-1-1B-1-2-3-1-1', 'JCY3-7-1-2-1-'B-1-1-4-1', 'JCY3-7-1-2-1-'B-2-3-2-1-2-3', 'CML3', 'CM117-3-4-1-1-4-1', 'CM117-3-4-1-2-5-1', '42048 -2-2-1-1-1-2', 'CML 33', 'JCY 3-7-1-2-1-'B-2-3-2-1-2-1','SW-93D-313-23-POP.49-S4-1', 'JCY 3-7-1-2-1-B-2-3-2-7-1-2-2', 'JCY3-7-1- 2-1-B-2-3-2-1-3-1','JCY 3-7-1-2-2-1-3-1-1-2-7-1-2- 5', 'JCY 2-2-4-1-1-1-3-1-3-1','42050-1-1-2-1-3', 'JCY 3-7-1-2-1-B-1-1-2-3-1-1', 'CM 117-3-4-1-2-5- 2', 'JCY 3-7-1-2-2-1-3-1-1-2-7-1-1-1', 'LM 13', 'CM 117-3-4-1-2-2-3','JCY3-7-1-2-1-B-2-1-2-1','SW9 3 D -313-23-POP.49-S4-1-3-1', 'CML 44', 'JCY3-7-1-2-1-b-2-3-2-3-1-1-1', 'LTP 1', 'LTP 4') were found resistant against post-flowering stalk rots (Hooda *et al.*,2012).

Table 2. Disease rating scale of Maize entries to charcoal rot disease in rabi 2021-2022

Sl. no.	Germplasms	Charcoal rot disease scale mean	Disease reaction
1	KML-1	5.99	MS
2	KML-2	4.33	MR
3	JCY-2-7	3.33	MR
4	KML-4	4.99	MR
5	KML-6	5.49	MS
6	KML-7	5.50	MS
7	KML-8	5.16	MS
8	KML-9	5.66	MS
9	KML-10	4.33	MS
10	KML-11	4.83	MS
11	KML-13	5.33	MS
12	KML-14	6.33	MS
13	KML-15	6.00	MS
14	KML-17	4.66	MR
15	KML-21	5.33	MS
16	KML-22	5.16	MS
17	KML-24	6.16	MS
18	KML-25	7.33	S
19	KML-26	4.66	MR
20	KML-28	6.83	MS
21	KML-29	5.99	MS
22	KML-31	6.49	MS
23	KML-32	5.66	MS
24	KML-33	4.33	MR
25	KML-70	5.66	MS
26	KML-71	6.33	MS
27	KML-72	7.66	S
28	KML-74	5.08	MR
29	KML-75	5.83	MS
30	KML-76	4.99	MR
31	KML-77	5.49	MS
32	KML-78	4.99	MS
33	KML-79	5.33	MS
34	KML-80	5.66	MS

35	KML-81	5.99	MS
36	KML-82	4.16	MR
37	KML-83	5.99	MS
38	KML-85	7.33	S
39	KML-86	5.99	MS
40	KML-87	7.66	S
41	KML-88	7.83	S
42	KML-18	5.83	MS
43	KML-19	5.66	MS
44	KML-30	5.83	MS
45	KML-66	6.16	MS
46	KML-67	5.50	MS
47	KML-225	6.16	MS
48	PFSR-3	5.83	MS
49	KML-69	6.33	MS
50	KML-16	6.16	MS
Sl. no.	**Hybrids**	**Charcoal rot disease scale mean**	**Disease reaction**
51	KNMH-4211	4.99	MR
52	KNMH-4181	5.50	MS
53	KNMH-4191	5.83	MS
54	KNMH-4192	4.66	MR
55	KNMH-141	5.66	MS
56	KNMH-131	4.66	MR
57	KMH-396	4.66	MR
58	KMH-393	5.0	MR
59	KMH-793	5.16	MS
60	KMH-770	4.33	MR
61	KMH-275	5.16	MS
62	KMH-400	5.83	MS
63	KMH-242	5.16	MS
64	KMH-247	5.33	MS
65	KMH-240	6.49	MS
66	KMH-246	5.49	MS
67	KMH-394	6.33	MS
68	KMH-498	5.83	MS
69	KMH-489	6.16	MS
70	KMH-506	6.33	MS
71	KMH-496	6.00	MS
72	KMH-493	5.49	MS
73	KMH-388	6.33	MS
74	KMH-387	6.83	MS
75	KMH-403	5.83	MS
76	KMH-373	5.83	MS
77	KMH-501	6.16	MS
78	KMH-500	5.49	MS
79	KMH-499	5.49	MS
80	KMH-505	5.99	MS
81	KMH-276	6.16	MS
82	KMH-271	5.16	MS
83	KMH-286	4.99	MR
84	KMH-275	4.66	MR
85	KMH-281	5.33	MS
86	KMH-318	4.33	MR
87	KMH-322	6.66	MS
88	K8322	6.33	MS
89	P3546	6.33	MS
90	NK6240	5.49	MS

91	GK3128	5.83	MS
92	PAC751	5.16	MS
93	LG-3603	5.83	MS
94	S-6668	4.66	MR
95	Kaveriekka	7.83	S
96	KMH-253	4.66	MR
97	KMH-262	4.99	MR
98	KMH-258	5.83	MS
99	KMH-268	5.16	MS
100	KMH-256	5.99	MS
101	KMH-415	5.83	MS
102	KMH-414	6.16	MS
103	KMH-307	5.83	MS
104	KMH-308	5.32	MS
105	KMH-311	5.32	MS
106	KMH-314	5.66	MS
107	KMH-306	5.66	MS
108	KMH-245	5.49	MS
109	KMH-235	5.33	MS
110	KMH-238	5.33	MS
111	KMH-237	5.99	MS
112	KMH-236	5.83	MS
113	KMH-243	6.16	MS
114	KMH-242	7.16	S
115	KMH-18	6.83	MS
116	KMH-20	5.66	MS
117	KMH-777	4.99	MR
118	KMH-762	5.16	MS
119	KMH-768	5.66	MS
120	KMH-433	4.99	MR
121	KMH-431	3.99	MR
122	KMH-25	4.99	MR
123	KMH-336	5.33	MS
124	KMH-335	5.33	MS
125	KMH-340	4.99	MR
126	KMH-343	5.33	MS
127	KMH-341	4.66	MR
128	KMH-332	5.49	MS
129	KMH-331	4.99	MR
130	KMH-337	4.66	MR
131	KMH-339	5.99	MS
132	KMH-471	4.66	MR
133	KMH-470	5.33	MS
134	KMH-469	4.83	MR
135	KMH-586	3.66	MR
136	KMH-472	5.83	MS
137	KMH-363	5.49	MS
138	KMH-357	4.83	MR
139	KMH-358	5.16	MS
140	KMH-367	4.49	MR
141	KMH-359	5.49	MS
142	KMH-482	5.66	MS
143	KMH-542	4.66	MR
144	KMH-544	4.49	MR
145	KMH-543	4.83	MR
146	KMH-919	5.33	MS
147	KMH-131	4.83	MR

148	KMH-128	5.33	MS
149	KMH-916	5.49	MS
150	KMH-249	5.33	MS
151	KMH-266	7.16	S
152	KMH-407	5.83	MS
153	KMH-479	5.33	MS
154	KMH-480	6.83	MS
155	KMH-459	5.33	MS
156	KMH-478	5.83	MS
157	KMH-475	6.66	MS
158	KMH-483	7.33	S
159	KMH-457	5.49	MS
160	KMH-370	6.16	MS
161	KMH-367	5.66	MS
162	KMH-369	5.83	MS
163	KMH-363	5.83	MS
164	KMH-382	5.66	MS
165	KMH-408	5.49	MS
166	KMH-588	5.33	MS
167	KMH-466	6.33	MS
168	KMH-467	6.16	MS
169	KMH-257	5.49	MS
170	KMH-385	5.49	MS
171	KMH-106	5.49	MS
172	KMH-107	6.16	MS
173	KMH-367	5.49	MS
174	KMH-394	5.0	MR
175	KMH-400	4.66	MR
176	KMH-377	5.16	MS
177	KMH-365	6.0	MS
178	KMH-364	5.49	MS
179	KMH-420	6.49	MS
180	KMH-387	5.66	MS
181	KMH-151	6.33	MS
182	KMH-327	5.16	MS
183	KMH-388	5.66	MS
184	KMH-574	5.66	MS
185	KMH-573	5.33	MS
186	KMH-392	5.16	MS
187	KMH-456	5.66	MS
188	KMH-450	5.49	MS
189	KMH-449	5.33	MS
190	KMH-461	5.66	MS
191	KMH-458	6.0	MS
192	KMH-457	5.83	MS
193	KMH-460	5.66	MS
194	KMH-459	5.49	MS
195	KMH-41	5.66	MS
196	KMH-36	5.66	MS
197	KMH-545	4.66	MR
198	KMH-540	5.16	MS
199	KMH-546	5.66	MS
200	KMH-194	4.83	MR
201	KMH-77	5.66	MS
202	KMH-64	8.83	S
203	KMH-565	5.66	MS
204	DHM-121	4.66	MR

205	SAMRATH	5.83	MS
206	HT-5402	6.0	MS
207	P-3401	6.33	MS
208	NK-6514	6.33	MS
209	DHM-117	5.33	MS
210	BIO-9544	4.33	MR
211	HT5106	4.66	MR
212	NK6802	5.0	MR
Check	Kaveri-50	8.10	S

R: Resistant, MR: Moderately Resistant, MS: Moderately Susceptible, S: Susceptible

Table 3. Disease rating scale of maize entries to charcoal rot disease in kharif-2022

Sl no.	Germplasms	Charcoal rot disease scale mean	Disease reaction
1	KML-1	5.50	MS
2	KML-2	6.00	MS
3	KML-4	5.75	MS
4	KML-5	4.75	MR
5	KML-6	5.0	MR
6	KML-7	4.50	MR
7	KML-8	4.75	MR
8	KML-9	5.25	MS
9	KML-10	5.50	MS
10	KML-11	5.50	MS
11	KML-12	5.75	MS
12	KML-13	5.25	MS
13	KML-14	4.50	MR
14	KML-15	5.25	MS
15	KML-16	5.75	MS
16	KML-17	6.00	MS
17	KML-19	5.00	MR
18	KML-20	5.00	MR
19	KML-21	5.00	MR
20	KML-22	5.50	MS
21	KML-24	6.00	MS
22	KML-25	6.75	MS
23	KML-26	6.50	MS
24	KML-27	6.00	MS
25	KML-28	5.50	MS
26	KML-29	5.50	MS
27	KML-30	5.75	MS
28	KML-31	4.75	MR
29	KML-32	6.25	MS
30	KML-33	5.25	MS
31	KML-34	4.50	MR
32	KML-36	4.25	MR
33	KML-37	6.25	MS
34	KML-41	4.00	MR
35	KML-43	3.5	MR
36	KML-44	6.0	MS
37	KML-45	4.5	MR
38	KML-46	4.75	MR

39	KML-47	4.45	MR
40	KML-48	5.5	MS
41	KML-49	6.00	MS
42	KML-50	6.00	MS
43	KML-51	5.50	MS
44	KML-52	5.00	MR
45	KML-53	5.50	MS
46	KML-54	5.25	MS
47	KML-55	4.50	MR
48	KML-56	6.00	MS
49	KML-57	5.25	MS
50	KML-58	6.25	MS
51	KML-59	6.25	MS
52	KML-60	5.5	MS
53	KML-61	6.25	MS
54	KML-62	5.50	MS
55	KML-63	5.0	MR
56	KML-64	5.0	MR
57	KML-65	5.25	MS
58	KML-66	6.00	MS
59	KML-67	6.00	MS
60	KML-69	6.25	MS
61	KML-70	6.5	MS
62	KML-71	6.25	MS
63	KML-72	6.25	MS
64	KML-73	4.50	MR
65	KML-74	5.00	MR
66	KML-75	5.75	MS
67	KML-76	5.50	MS
68	KML-77	4.50	MR
69	KML-78	3.75	MR
70	KML-79	5.25	MS
71	KML-80	5.25	MS
72	KML-81	4.50	MR
73	KML-82	5.25	MS
74	KML-83	6.00	MS
75	KML-85	5.75	MS
76	KML-86	6.75	MS
77	KML-87	4.50	MS
78	KML-88	5.50	MS
79	KML-225	5.50	MS
80	PFSR-3	6.00	MS
Sl no.	**Hybrids**	**Charcoal rot disease scale mean**	**Disease reaction**
1	KMH-886	5.75	MS
2	KMH-890	5.50	MS
3	KMH-881	4.75	MR
4	KMH-882	7.25	S
5	KMH-885	5.50	MS
6	KMH-868	5.25	MS
7	KMH-871	5.50	MS
8	KMH-867	5.25	MS

9	KMH-869	5.50	MS
10	KMH-872	5.50	MS
11	KMH-876	6.00	MS
12	KMH-875	5.25	MS
13	KMH-127	5.25	MS
14	KMH-610	6.25	MS
15	KMH-917	5.75	MS
16	KMH-924	6.00	MS
17	KMH-918	5.00	MR
18	KMH-26	5.00	MR
19	KMH-18	5.75	MS
20	KMH-921	4.50	MR
21	KMH-922	5.50	MS
22	KMH-915	4.75	MR
23	KMH-916	6.25	MS
24	KMH-926	5.25	MS
25	KMH-111	5.75	MS
26	KMH-138	7.00	MS
27	KMH-125	7.50	S
28	KMH-107	6.25	MS
29	KMH-136	5.25	MS
30	KMH-132	7.75	S
31	KMH-109	5.75	MS
32	KMH-139	6.00	MS
33	KMH-152	2.75	R
34	KMH-169	4.75	MR
35	KMH-935	5.75	MS
36	KMH-40	5.75	MS
37	KMH-22	4.25	MR
38	KMH-94	6.25	MS
39	KMH-91	5.00	MR
40	KMH-69	5.25	MS
41	KMH-842	5.25	MS
42	KMH-156	7.00	MS
43	KMH-101	5.25	MS
44	KMH-839	6.00	MS
45	KMH-163	5.50	MS
46	KMH-766	6.50	MS
47	KMH-151	5.50	MS
48	KMH-160	6.25	MS
49	KMH-157	6.00	MS
50	KMH-162	6.50	MS
51	KMH-71	6.00	MS
52	KMH-161	6.50	MS
53	KMH-843	5.50	MS
54	KMH-195	5.25	MS
55	KMH-767	5.25	MS
56	KMH-773	5.25	MS
57	KMH-102	6.75	MS
58	KMH-743	6.75	MS
59	KMH-775	6.75	MS
60	KMH-769	5.50	MS

61	KMH-846	4.50	MR
62	KMH-838	5.50	MS
63	KMH-766	5.25	MS
64	KMH-103	4.75	MR
65	KMH-765	5.75	MS
66	KMH-789	6.75	MS
67	KMH-786	5.75	MS
68	KMH-819	6.75	MS
69	KMH-823	7.75	S
70	KMH-788	5.50	MS
71	KMH-78	5.75	MS
72	KMH-131	6.00	MS
73	KMH-813	4.00	MR
74	KMH-68	6.00	MS
75	KMH-782	5.25	MS
76	KMH-811	5.75	MS
77	KMH-73	7.00	MS
78	KMH-62	5.75	MS
79	KMH-124	5.50	MS
80	KMH-98	7.75	S
81	KMH-794	6.50	MS
82	KMH-814	6.25	MS
83	KMH-856	5.75	MS
84	KMH-77	6.50	MS
85	KMH-865	5.50	MS
86	KMH-816	4.75	MR
87	KMH-742	5.75	MS
88	KMH-780	5.75	MS
89	KMH-812	4.75	MR
90	KMH-907	4.00	MR
91	KMH-805	6.75	MS
92	KMH-804	4.50	MR
93	KMH-58	4.00	MR
94	KMH-796	5.25	MS
95	KMH-55	4.75	MR
96	KMH-902	5.00	MR
97	KMH-722	5.25	MS
98	KMH-806	5.25	MS
99	KMH-809	5.00	MR
100	KMH-799	4.75	MR
101	KMH-67	4.75	MR
102	KMH-854	4.00	MR
103	KMH-862	4.00	MR
104	KMH-800	4.75	MR
105	KMH-56	4.65	MR
106	KMH-798	4.75	MR
107	KMH-808	4.75	MR
108	KMH-802	4.50	MR
109	KMH-901	4.75	MR
110	KMH-905	4.50	MR
111	KMH-815	4.75	MR
112	KMH-858	5.50	MS

113	KMH-76	4.75	MR
114	KMH-783	5.00	MR
115	KMH-863	4.50	MR
116	KMH-866	4.50	MR
117	KMH-855	5.25	MS
118	KMH-57	4.00	MR
119	KMH-859	5.25	MS
120	KMH-795	4.75	MR
121	KMH-793	4.75	MR
122	KMH-752	5.75	MS
123	KMH-787	5.25	MS
124	KMH-753	5.25	MS
125	KMH-746	5.25	MS
126	KMH-754	6.75	MS
127	KMH-755	5.50	MS
128	KMH-756	7.50	S
129	KMH-757	5.75	MS
130	KMH-747	5.00	MR
131	KMH-758	4.75	MR
132	KMH-759	5.75	MS
133	KMH-760	5.25	MS
134	KMH-750	5.25	MS
135	KMH-748	6.75	MS
136	KMH-763	5.50	MS
137	KMH-745	7.50	S
138	KMH-744	5.75	MS
139	KMH-761	5.75	MS
140	KMH-749	5.75	MS
141	KMH-751	5.50	MS
142	KMH-725	7.25	S
143	KMH-722	7.25	S
144	KMH-729	5.25	MS
145	KMH-730	4.75	MR
146	KMH-723	6.00	MS
147	KMH-731	6.75	MS
148	KMH-732	6.50	MS
149	KMH-733	6.25	MS
150	KMH-734	5.50	MS
151	KMH-726	5.50	MS
152	KMH-728	7.50	S
153	KMH-741	8.00	S
154	KMH-163	7.25	S
155	KMH-740	5.75	MS
156	KMH-739	5.50	MS
157	KMH-738	5.50	MS
158	KMH-737	6.75	MS
159	KMH-904	5.75	MS
160	KMH-724	5.25	MS
161	KMH-735	7.00	MS
162	KMH-742	5.50	MS
163	KMH-736	5.25	MS
164	S-6668	4.50	MR

165	PAC-751	5.75	MS
166	NK-30	5.50	MS
167	B-9144	6.00	MS
168	NK-6802	5.75	MS
169	DKC-9198	6.00	MS
170	DKC-9173	4.25	MR
171	P-3302	6.00	MS
172	P-3401	5.75	MS
173	NK-6240	5.25	MS
174	Kaveriekka	4.50	MR
175	IQ-8319	5.00	MR
176	IQ-8220	3.75	MR
177	8227-C	4.25	MR
178	NMH-007(Bond)	5.00	MR
179	NMH-1258	5.00	MR
180	NMH-4144	5.75	MS
181	K NMH-131	6.25	MS
182	KNMH-141	6.50	MS
183	KNMH-4191	4.50	MR
184	NK-6514	5.50	MS
185	B-8135	4.50	MR
186	Bio-9544	5.50	MS
187	SAMARTH	5.50	MS
188	PAC-751 elite	5.75	MS
189	HT-5109	5.50	MS
190	HT-5402	5.50	MS
191	DKC-7074	5.50	MS
192	DHM-182	5.50	MS
193	DHM-117	5.50	MS
194	DHM-121	7.25	S
195	PAC-741	6.25	MS
196	CM-202	4.25	MR
197	CM-300	5.50	MS
198	CM-600	6.00	MS
199	Chakara	6.00	MS
Check	Kaveri-50	8.00	S

R: Resistant, MR: Moderately Resistant, MS: Moderately Susceptible, S: Susceptible

Out of 80 elite inbreds, only 12 inbreds (PFSR/51016-1, CM144, HKI 193-1, PFSR- R2, PFSR-R9, JCY2-1-2-1-1B-1-2-3-1-1, CM117-3-4-1-2-5-2, 42048-2-2-1-1-1-2, JCY3-7-1-2-2-1-3-1-1-2-7-1-1-1, JCY2-7-1-2-1-B-1-2-1-1, LM13 and CM117-3-4-1-2-2-3) had mean disease incidence ≤ 3.0 were identified PFSR disease resistance sources for different maize agro ecologies in India [17].

Out of 12, Only three cultivars (FH-1228, FH-1025 and FH-1225) were scored as a moderately resistant to charcoal rot disease [18,19].

According to Madhu *et al.,* 2021, Screening of 98 maize genotypes in field against *M.phaseolina*, only four lines viz., MGC-237,MGC-248,MGC-254,MGC-256 and two testers, viz., BML-6 and GP-311 and 15 crosses 311 were found resistant to charcoal rot disease [20,21].

Kalpana et al., 2022, also reported on maize against *Fusarium verticilliodes* and identifies eight genotypes AH1625, BAU-MH-18-2, GGMH-114, GK 3207, CMH-12-686, CAH 1511, ADH 1619 and FQH-148 with stable resistance.

37 maize genotypes against the *M. phaseolina* pathogen, the inbred line PFSR 135 and three testers viz., CML 286, CML 4541, and BML 7

were noticed resistance to the charcoal rot disease [7].

4. CONCLUSION

In order to identified charcoal rot disease resistant lines, screening of 492 maize entries in field against *M.phaseolina* was done. Only one line KMH-152 was found resistant.

Whereas,123 entries namely KML-2,JCY-2-7,KML-4, KML-17, KML-26, KML-33, KML-74, KML-76, KML-82, KNMH-4211, KNMH-4192, KNMH-131, KMH-396, KMH-393, KMH-770, KMH-286, KMH-275, KMH-318, S-6668, KMH-253, KMH-262, KMH-777, KMH-433, KMH-431, KMH-25, KMH-340, KMH-341, KMH-331, KMH-337, KMH-471, KMH-469, KMH-586, KMH-357, KMH-367, KMH-542, KMH-544, KMH-543, KMH-131, KMH-394, KMH-400, KMH-545, KMH-194, DHM-121, BIO-9544, HT5106, NK6802, KML-5, KML-6, KML-7, KML-8, KML-14, KML-19, KML-20, KML-21, KML-31, KML-34, KML-36, KML-41, KML-43, KML-45, KML-46, KML-47, KML-52, KML-55, KML-63, KML-64, KML-73, KML-74, KML-77, KML78, KML-81, KMH-881, KMH-918, KMH-26, KMH-921, KMH-915, KMH-169, KMH-22, KMH-91, KMH-846, KMH-103, KMH-813, KMH-816, KMH-812, KMH-907, KMH-804, KMH-58, KMH-55, KMH-902, KMH-809, KMH-799, KMH-67, KMH-854, KMH-862, KMH-800, KMH-56, KMH-798, KMH-808, KMH-802, KMH-901, KMH-905, KMH-815, KMH-76, KMH-783, KMH-863, KMH-866, KMH-57, KMH-795, KMH-793, KMH-747, KMH-758, KMH-730, S-6668, DKC-9173, Kaveriekka, IQ-8319, IQ-8220, 8227-C, NMH-007, NMH-1258, KNMH-4191, CM-202 and B-8135 were found moderately resistant to charcoal rot disease. As a result, most of the genotypes exhibited disease reaction varying from resistant (score 3) to moderately susceptible (score7) against *Macrophomina phaseolina.*

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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