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Identification of Resistant Entries Against Charcoal Rot Caused by *Macrophomina phaseolina* in Maize (*Zea mays* L.)

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ABSTRACT

The experiment was conducted from November, 2022 to February, 2023 (*rabi* season) and July, 2023 to October, 2023 (*kharif* season) respectively at the Agricultural Research Station, Karimnagar, Telangana State, India to identify resistant hybrids for charcoal rot disease in maize. 469 entries with check were screened in randomized block design by tooth pick method of inoculation. During *rabi,* 2022–23, out of screened 275 (274+1) lines, one hybrid KMH-42283 was found resistant, 24 lines viz., KML-79, KML-52, KML-54, KML-10, KML-75, KML-34, KML-72, KML-80, KML-29, KML-61, KML-1, KML-5, KMH-422730, KMH-422758, KMH-422752, KMH-422753, KMH-42229, KMH-422788, KMH-422777, KMH-42284, KMH-42247, KMH-422972, KMH-422838 and KMH-421353 were found moderately resistant, Kaveri-50 (Check) entry has recorded 8.10 disease scale and remaining lines were found moderately susceptible and susceptible to charcoal rot disease. During *kharif,* 2023, out of screened 193 lines, 33 lines viz., KML-95, KML-109, KML-5, KML-102, KML-107, KML-25, KML-65, KML-114, KML-118, KML-49, KMH-422302, KMH-422307, KMH-422475, KMH-422325, KMH-422333, KMH-422381, KMH-422382, KMH-422383, KMH-422384, KMH-422391, KMH-422397, KMH-422590, KMH-422480, KMH-422518, NK-7702, DHM-121, DKC-9178, DKC-9233, P-3401, P-3302, KNMH-131, PAC-751 elite and GK-3237 were identified as moderately resistant to charcoal rot disease, one line Kaveri-50 (check) was severely affected by charcoal rot with 8.20 disease rating and rated as susceptible during *kharif*, 2023.

KEYWORDS: Charcoal rot, germplasms, hybrids, maize, screening, toothpick

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1. INTRODUCTION

Maize (*Zea mays* L. 2n=20) is known as Miracle crop and Queen of cereals. The maize is a Versatile crop with multiple types and uses including grain/fodder/silage/baby corn/popcorn/sweet corn,etc.It has the highest genetic yield potential among the cereal crops and serves as an important raw material for various agro-based industries. Globally, it has the highest productivity (5.7 t ha^{-1}) with largest production (1163 mt) amongst cereal in the world. It is being grown in >160 countries with 203.5 mha acre age. In India, the crop is now being grown throughout the year in one or other part of the country, as a result, 2–3 crops can be taken annually in most of the states.In last two decades,with adoption of single cross hybrids and improved production technologies,the area, production and productivity is increasing continuously. Thus, India has turned from importer to exporter of maize grain/seed, baby corn, sweet corn, etc. and it'svalue added products including feed, starch, grits, etc. In India, it is the third most important cereal crop after rice and wheat. The crop has diverse agroecology and is grown throughout the country from Kashmir to Kanya Kumari. In India, Maize is grown in an area of10.04 mhawith a production of 333.62 mt and productivity of 3,349 kg ha^{-1}. In Telangana state, maize occupies an area of 0.41 million hectares with a production of 2.13 mt and productivity of 5,178 kg ha^{-1} (Anonymous, 2022). Out of which, 0.12 lakh 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 (Sharma et al., 1993). PFSR is a complex disease of maize, which commonly appears when there is scarcity of irrigation coupled with high soil temperature at 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, Uttar Pradesh, Punjab, Madhya Pradesh and West Bengal. The disease incidence, recorded in India time to time, ranged from 10.0 to 42.0% (Desai et al., 1991), 13.2 to 39.5% (Payak and Sharma, 1985), 25.0 to 32.0% (Kumar et al., 1998), 10.0 to 42.0% (Harlapur et al., 2002) and in recent years yield reduction has been reported to be as high as 22.3 to 63.5% (Anonymous, 2014).

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 (Nagy and Cabulea, 1996). 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 (Shekhar et al., 2010, Hooda et al., 2012) and abroad (Clark and Foley, 1985). 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 (Anonymous, 2012). Kalpana et al., 2022 identified few maize lines resistance to *Fusarium verticilliodes* at Udaypur. Rotting symptoms in the inoculated stalks become prominent only at harvesting stage. The objective of this study was to assess the maize inbred lines and hybrids for resistance to charcoal rot disease under field conditions. Accordingly, the present study was carried out by screening four hundred and sixty nine maize entries for identification of resistant sources against charcoal rot disease.

2. MATERIALS AND METHODS

Four hundred and sixty nine (genotypes, hybrids and check) entries were evaluated by raising the crop in charcoal rot disease sick plot accompanied by toothpick inoculation during *rabi*, 2022–2023 and *kharif*, 2023 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 sixty nine 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 [Hooda et al., 2018]. The test genotypes were planted in 2 rows of 3 m length each with a plant spacing of 60×20 cm^2. Screening reinforced with artificial inoculation using tooth pick method is effective in supplementing the disease sick plot technique of screening against charcoal rot. The methodology followed is suitable for screening against a multi-pathogen disease complex (Shankar Lingam and Venkatesh, 2005). 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 (Anonymous, 2012 and Hooda et al., 2018. Before inoculation, one jabber was made by driving/fixing a nail of toothpick size into a wooden handle. For inoculation, most appropriate plant stage for inoculation is between tasseling and pollination for that the lower inter node (second or third) above soil level was selected. Then the pointed head of the nail was pushed carefully into the selected inter node to make a hole of desired length (2 cm). 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 (1983) and Hooda et al., 2018 was followed for scoring and scale has been unequally distributed into four categories of disease severity (Table 1),

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:3.1-5.0)
5	Less than 50% discolouration of the adjacent internode	
6	More than 50% discolouration of the adjacent internode	Moderately susceptible (Score:5.1-7.0)
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	

All data on the disease severity generated from the experiments conducted in field was assessed atthe end viz., Resistant (R), Moderately Resistant (MR), Moderately Susceptible (MS) and Susceptible (S) reaction.

3. RESULTS AND DISCUSSION

Disease severity/score of maize entries, which were artificially inoculated under field conditions during *rabi,* 2022–2023 and *kharif,* 2023 to charcoal rot disease was observed. The performance of 469 entries along with susceptible check on the basis of disease reaction on 1-9 disease scale was classified into four groups (Tables 2-6).

3.1. Disease reaction during rabi 2022–2023 screening of maize genotypes in field

Out of the 69 lines screened against *M. phaseolina*, twelve lines viz., KML-79, KML-52, KML-54, KML-10, KML-75, KML-34, KML-72, KML-80, KML-29, KML-61, KML-1 and KML-5 were found moderately resistant, 47 lines were moderately susceptible and the remaining lines were found susceptible in *rabi,* 2022–2023 (Table 2).

Among the 206 hybrids, one hybrid KMH-42283 was found resistant, 12 hybrids,viz.,KMH-422730, KMH-422758, KMH-422752, KMH-422753, KMH-42229, KMH-422788, KMH-422777, KMH-42284, KMH-42247, KMH-422972, KMH-422838 and KMH-421353 were found moderately resistant,156 hybrids were found moderately susceptible and 37 hybrids were found susceptible to charcoal rot disease during *rabi* 2022–2023 (Tables 3 and Table 4).

3.2. Disease reaction during kharif-2023 screening of maize genotypes in field

Out of the 52 lines screened against *M. phaseolina*, one line KML-39 was found resistant, only 10 lines, viz., KML-95, KML-109, KML-5, KML-102, KML-107, KML-25, KML-65, KML-114, KML-118 and KML-49 were found moderately resistant, 37 lines were found moderately susceptible and 4 germplasms were found susceptible to charcoal rot disease in *kharif*-2023 (Table 6).

Among the 142 hybrids, 23 hybrids viz., KMH-422302, KMH-422307, KMH-422475, KMH-422325, KMH-422333, KMH-422381, KMH-422382, KMH-422383, KMH-422384, KMH-422391, KMH-422397, KMH-422590, KMH-422480, KMH-422518, NK-7702, DHM-121, DKC-9178, DKC-9233, P-3401, P-3302, KNMH-131, PAC-751 elite and GK-3237 were found moderately resistant,111 hybrids were found moderately susceptible and 8 hybrids were found susceptible during *kharif*-2023 (Tables 5 and Table 6).

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

Table 2: Disease rating scale of maize entries to charcoal rot disease in *rabi,* 2022–2023

Sl. No.	Germplasms	Disease scale mean	Reaction	Sl no.	Germplasms	Disease scale mean	Reaction
1.	KML-25	5.75	MS	36.	KML-70	5.5	MS
2.	KML-78	6.75	MS	37.	KML-71	6.5	MS
3.	KML-24	7.0	MS	38.	KML-43	7.5	S
4.	KML-57	6.0	MS	39.	KML-66	6.5	MS
5.	KML-59	6.25	MS	40.	KML-80	3.5	MR
6.	KML-27	7.0	MS	41.	KML-37	6.0	MS
7.	KML-77	7.25	S	42.	KML-36	7.0	MS
8.	KML-58	6.75	MS	43.	KML-64	6.0	MS
9.	KML-79	5.0	MR	44.	KML-65	5.25	MS
10.	KML-55	7.0	MS	45.	KML-32	5.5	MS
11.	KML-20	8.0	S	46.	KML-7	7.5	S
12.	KML-19	6.5	MS	47.	KML-63	6.75	MS
13.	KML-56	7.0	MS	48.	KML-31	5.5	MS
14.	KML-52	5.0	MR	49.	KML-62	6.5	MS
15.	KML-22	6.0	MS	50.	KML-30	6.0	MS
16.	KML-54	3.5	MR	51.	KML-60	5.5	MS
17.	KML-51	7.5	S	52.	KML-29	4.5	MR
18.	KML-17	8.0	S	53.	KML-61	5.0	MR
19.	KML-16	6.0	MS	54.	KML-33	5.25	MS
20.	KML-53	6.0	MS	55.	KML-28	6.0	MS
21.	KML-14	7.0	MS	56.	KML-67	6.75	MS
22.	KML-13	7.5	S	57.	KML-1	4.0	MR
23.	KML-11	6.5	MS	58.	KML-15	5.5	MS
24.	KML-12	7.0	MS	59.	KML-47	6.0	MS
25.	KML-49	6.5	MS	60.	KML-5	7.5	S
26.	KML-10	5.0	MR	61.	KML-6	5.0	MR
27.	KML-48	7.5	S	62.	KML-73	6.0	MS
28.	KML-76	7.5	S	63.	KML-26	6.5	MS
29.	KML-46	6.25	MS	64.	KML-28	6.5	MS
30.	KML-75	4.5	MR	65.	KNMH-4191	6.0	MS
31.	KML-9	6.0	MS	66.	KNMH-141	6.5	MS
32.	KML-34	4.0	MR	67.	KNMH-131	5.75	MS
33.	KML-72	4.5	MR	68.	PFSR-3	5.75	MS
34.	KML-44	6.0	MS	69.	KML-225	6.75	MS
35.	KML-69	6.5	MS	Check	Kaveri-50	8.10	S

Macrophomina phaseolina (Shekhar et al., 2010).

Twenty inbred lines of maize were tested by Kaur et al., 2010 in 2005 and 2006 under artificial epiphytotic conditions for the *M. phaseolina*. One genotype, E-10 LET DR99×Ent 49-2 was identified as resistant line to charcoal rot disease. 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,

Table 3: Disease rating scale of Maizeentries to charcoal rot disease in *rabi*, 2022–2023

Sl. No.	Hybrids	Disease scale mean	Reaction	Sl. No.	Hybrids	Disease scale mean	Reaction	Sl. No.	Hybrids	Disease Scale mean	Reaction
1.	KMH422729	7.75	S	35.	KMH422867	7.25	S	69.	KMH42218	6.75	MS
2.	KMH422723	5.75	MS	36.	KMH422872	7.0	MS	70.	KMH42221	8.0	S
3.	KMH422726	6.0	MS	37.	KMH422925	7.75	S	71.	KMH422987	5.75	MS
4.	KMH422122	5.25	MS	38.	KMH422922	5.75	MS	72.	KMH42223	6.5	MS
5.	KMH422730	4.75	MR	39.	KMH422919	6.75	MS	73.	KMH42222	6.5	MS
6.	KMH422743	6.25	MS	40.	KMH422924	7.75	S	74.	KMH422902	6.0	MS
7.	KMH422732	6.5	MS	41.	KMH422748	8.25	S	75.	KMH422900	6.5	MS
8.	KMH422724	7.75	S	42.	KMH422928	6.5	MS	76.	KMH422903	7.25	S
9.	KMH422731	8.0	S	43.	KMH422930	6.0	MS	77.	KMH422901	6.25	MS
10.	KMH422727	5.75	MS	44.	KMH422802	6.5	MS	78.	KMH422910	5.5	MS
11.	KMH422728	5.25	MS	45.	KMH422798	6.5	MS	79.	KMH422905	6.0	MS
12.	KMH422722	6.0	MS	46.	KMH422799	5.75	MS	80.	KMH422909	6.5	MS
13.	KMH422185	7.25	S	47.	KMH422859	5.5	MS	81.	KMH422855	6.75	MS
14.	KMH422741	5.5	MS	48.	KMH422556	7.5	S	82.	KMH422862	6.66	MS
15.	KMH422733	6.0	MS	49.	KMH422865	6.5	MS	83.	KMH422858	5.5	MS
16.	KMH422735	6.5	MS	50.	KMH422863	6.0	MS	84.	KMH422938	6.0	MS
17.	KMH422998	6.5	MS	51.	KMH422854	6.5	MS	85.	KMH422923	7.75	S
18.	KMH422997	5.25	MS	52.	KMH422796	8.0	S	86.	KMH422963	7.75	S
19.	KMH422996	7.5	S	53.	KMH42248	6.75	MS	87.	KMH422946	6.75	MS
20.	KMH422759	5.75	MS	54.	KMH42259	7.75	S	88.	KMH422926	6.25	MS
21.	KMH422745	8.75	S	55.	KMH42258	6.5	MS	89.	KMH422961	5.75	MS
22.	KMH422744	6.25	MS	56.	KMH42256	5.75	MS	90.	KMH422960	5.25	MS
23.	KMH422746	6.75	MS	57.	KMH42246	6.5	MS	91.	KMH422969	5.75	MS
24.	KMH422749	7.75	S	58.	KMH42249	5.25	MS	92.	KMH422965	7.0	MS
25.	KMH422755	5.75	MS	59.	KMH42227	6.25	MS	93.	KMH422955	7.5	S
26.	KMH422758	4.75	MR	60.	KMH42228	6.25	MS	94.	KMH422958	6.0	MS
27.	KMH422752	3.5	MR	61.	KMH42231	6.75	MS	95.	KMH422779	6.5	MS
28.	KMH422753	4.75	MR	62.	KMH42232	5.75	MS	96.	KMH422885	6.5	MS
29.	KMH422747	6.5	MS	63.	KMH42230	8.0	S	97.	KMH422883	6.0	MS
30.	KMH422754	7.75	S	64.	KMH42252	6.75	MS	98.	KMH422890	6.5	MS
31.	KMH422757	6.75	MS	65.	KMH42251	5.5	MS	99.	KMH422886	7.0	MS
32.	KMH422750	5.75	MS	66.	KMH42229	4.0	MR	100.	KMH422882	6.5	MS
33.	KMH422880	6.5	MS	67.	KMH42243	6.75	MS	101.	KMH422845	8.0	S
34.	KMH422876	6.0	MS	68.	KMH42299	8.0	S	102.	KMH422843	5.5	MS

P 408, E 684, P 364, E 613, P 345, 18855 were moderately resistant in field (Gopala et al., 2016).

A set of 200 elite maize lines was screened against PFSR diseases at 9 different geographical locations of India. Out of them one hundred twenty-one elite lines were found resistant against post-flowering stalk rots (Hooda et al., 2012).

Out of 80 elite inbreds, only 12 inbreds (PFSR/51016-1,

Table 4: Disease rating scale of maize entries to charcoal rot disease in *rabi*, 2022-2023

Sl. No.	Hybrids	Disease scale mean	Re-ac-tion	Sl. No.	Hybrids	Disease scale mean	Reac-tion	Sl. No.	Hybrids	Disease scale mean	Reac-tion
103.	KMH422851	6.5	MS	137.	KMH42282	6.0	MS	171.	KMH422809	7.0	MS
104.	KMH422962	5.25	MS	138.	KMH42284	4.0	MR	172.	KMH422957	6.0	MS
105.	KMH422846	5.5	MS	139.	KMH42271	5.75	MS	173.	KMH422962	5.5	MS
106.	KMH422787	6.0	MS	140.	KMH42292	6.5	MS	174.	KMH422971	6.0	MS
107.	KMH422842	7.0	MS	141.	KMH422917	5.75	MS	175.	KMH422972	5.0	MR
108.	KMH422780	6.5	MS	142.	KMH422921	6.75	MS	176.	KMH422967	5.5	MS
109.	KMH422881	6.5	MS	143.	KMH422920	6.0	MS	177.	KMH422956	7.0	MS
110.	KMH422788	5.0	MR	144.	KMH422824	6.25	MS	178.	KMH422866	6.0	MS
111.	KMH422841	6.5	MS	145.	KMH422839	6.5	MS	179.	KMH42238	5.5	MS
112.	KMH422847	7.75	S	146.	KMH422778	5.75	MS	180.	KMH422893	7.0	MS
113.	KMH422959	6.5	MS	147.	KMH422898	7.25	S	181.	KMH422945	7.25	S
114.	KMH422907	6.0	MS	148.	KMH422834	6.5	MS	182.	KMH422963	6.0	MS
115.	KMH422763	6.5	MS	149.	KMH422904	6.0	MS	183.	KMH422942	7.25	S
116.	KMH422770	5.5	MS	150.	KMH42220	6.5	MS	184.	KMH4229	7.0	MS
117.	KMH422775	6.5	MS	151.	KMH422994	7.5	S	185.	KMH42210	6.25	MS
118.	KMH422777	5.0	MR	152.	KMH422995	8.0	S	186.	KMH42216	6.75	MS
119.	KMH42291	6.5	MS	153.	KMH422734	8.5	S	187.	KMH42274	6.0	MS
120.	KMH42289	6.5	MS	154.	KMH422738	6.0	MS	188.	KMH42273	7.5	S
121.	KMH42288	6.0	MS	155.	KMH422811	6.75	MS	189.	KMH42213	6.0	MS
122.	KMH42293	6.5	MS	156.	KMH422742	6.0	MS	190.	KMH422838	3.5	MR
123.	KMH42272	6.0	MS	157.	KMH422740	7.0	MS	191.	KMH42214	6.0	MS
124.	KMH422793	5.5	MS	158.	KMH422725	6.0	MS	192.	KMH4228	7.5	S
125.	KMH422871	7.5	S	159.	KMH422741	7.0	MS	193.	KMH422751	6.0	MS
126.	KMH42271	6.25	MS	160.	KMH42250	7.5	S	194.	KMH422761	6.0	MS
127.	KMH42215	6.75	MS	161.	KMH42261	6.0	MS	195.	KMH422776	6.5	MS
128.	KMH422816	6.5	MS	162.	KMH42244	5.75	MS	196.	KMH422931	5.75	MS
129.	KMH422815	6.75	MS	163.	KMH42255	6.75	MS	197.	KMH421353	5.0	MR
130.	KMH422869	6.0	MS	164.	KMH42245	6.25	MS	198.	KMH421102	7.5	S
131.	KMH42283	2.5	R	165.	KMH42247	3.25	MR	199.	KMH421101	6.0	MS
132.	KMH42282	5.5	MS	166.	KMH422805	6.75	MS	200.	KMH421364	6.5	MS
133.	KMH42276	6.0	MS	167.	KMH422810	6.0	MS	201.	KMH42124	6.5	MS
134.	KMH42280	6.5	MS	168.	KMH422804	6.5	MS	202.	CM-300	5.75	MS
135.	KMH42279	6.75	MS	169.	DHM-182	5.5	MS	203.	CM-600	5.75	MS
136.	KMH42281	5.5	MS	170.	KMH422806	6.5	MS	204.	Chakra	7.0	MS
								205.	CM-202	7.5	S
								Check	Kaveri-50	8.10	S

Table 5: Disease rating scale of maize entries to charcoal rot disease in *kharif*, 2023

Sl. No.	Hybrids	Disease scale mean	Reaction	Sl. No.	Hybrids	Disease scale mean	Reaction	Sl. No.	Hybrids	Disease scale mean	Reaction
1.	KMH-422297	5.75	MS	35.	KMH-422417	5.75	MS	69.	KMH-422511	6.0	MS
2.	KMH-422295	5.5	MS	36.	KMH-422419	5.35	MS	70.	KMH-422512	6.0	MS
3.	KMH-422299	6.5	MS	37.	KMH-422418	6.75	MS	71.	KMH-422518	3.25	MR
4.	KMH-422302	5.0	MR	38.	KMH-422420	7.25	S	72.	KMH-422520	5.25	MS
5.	KMH-422307	4.5	MR	39.	KMH-422422	5.75	MS	73.	KMH-422526	6.25	MS
6.	KMH-422475	4.0	MR	40.	KMH-422424	5.75	MS	74.	KMH-422527	5.5	MS
7.	KMH-422474	5.5	MS	41.	KMH-422425	5.75	MS	75.	KMH-422529	6.0	MS
8.	KMH-422320	6.25	MS	42.	KMH-422430	6.0	MS	76.	KMH-422532	7.0	MS
9.	KMH-422325	4.0	MR	43.	KMH-422588	6.0	MS	77.	KMH-422534	5.75	MS
10.	KMH-422333	5.0	MR	44.	KMH-422589	8.0	S	78.	KMH-422535	5.75	MS
11.	KMH-422334	6.0	MS	45.	KMH-422590	5.0	MR	79.	KMH-422537	5.75	MS
12.	KMH-422335	5.75	MS	46.	KMH-422433	5.25	MS	80.	KMH-422538	6.25	MS
13.	KMH-422338	6.25	MS	47.	KMH-422434	6.0	MS	81.	KMH-422455	5.75	MS
14.	KMH-422340	5.50	MS	48.	KMH-422435	6.25	MS	82.	KMH-422453	5.75	MS
15.	KMH-422344	6.0	MS	49.	KMH-422436	6.0	MS	83.	KMH-422454	6.25	MS
16.	KMH-422346	5.25	MS	50.	KMH-422438	6.0	MS	84.	KMH-422540	5.5	MS
17.	KMH-422347	6.0	MS	51.	KMH-422480	5.0	MR	85.	KMH-422542	5.5	MS
18.	KMH-422348	6.0	MS	52.	KMH-422481	6.5	MS	86.	KMH-422543	5.5	MS
19.	KMH-422349	6.5	MS	53.	KMH-422479	7.0	MS	87.	KMH-422548	5.75	MS
20.	KMH-422363	5.25	MS	54.	KMH-422445	5.5	MS	88.	KMH-422549	7.25	S
21.	KMH-422381	4.0	MR	55.	KMH-422442	6.0	MS	89.	KMH-422551	7.0	MS
22.	KMH-422382	4.0	MR	56.	KMH-422446	5.5	MS	90.	KMH-422556	7.0	MS
23.	KMH-422383	4.5	MR	57.	KMH-422487	5.75	MS	91.	KMH-422568	7.25	S
24.	KMH-422384	4.0	MR	58.	KMH-422488	6.75	MS	92.	KMH-422578	5.75	MS
25.	KMH-422385	5.5	MS	59.	KMH-422489	5.75	MS	93.	KMH-422882	5.75	MS
26.	KMH-422389	7.0	MS	60.	KMH422-491	5.75	MS	94.	KMH-422212	6.5	MS
27.	KMH-422 391	4.25	MR	61.	KMH-422496	6.0	MS	95.	KMH-422225	6.25	MS
28.	KMH-422392	5.25	MS	62.	KMH-422497	5.5	MS	96.	KMH-422226	6.0	MS
29.	KMH-422397	4.75	MR	63.	KMH-422499	6.75	MS	97.	KMH-422210	5.75	MS
30.	KMH-422398	5.5	MS	64.	KMH-422503	5.75	MS	98.	KMH-422228	6.25	MS
31.	KMH-422400	6.25	MS	65.	KMH-422506	5.25	MS	99.	KMH-422230	6.25	MS
32.	KMH-422402	6.25	MS	66.	KMH-422509	5.75	MR	100.	KMH-422235	7.25	S
33.	KMH-422407	7.25	S	67.	KMH-422510	6.0	MS	101.	KMH-422236	5.75	MS
34.	KMH-422411	5.5	MS	68.	KMH-422511	6.0	MS	102.	KMH-422238	6.5	MS

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 agroecologies in India (Hooda et al., 2017).

Mir et al., 2018 screened set of maize inbreds for *F.*

Table 6: Disease rating scale of Maize entries to charcoal rot disease in *kharif*, 2023

S l . No.	Hybrids	Disease scale mean	Reac-tion	Sl. No.	Hybrids	Disease scale mean	Reac-tion	Sl. No.	Germ-plasms	Disease scale mean	Reac-tion
103.	KMH-422239	6.0	MS	138.	GK-3237	4.75	MR	171.	KML-124	6.25	MS
104.	KMH-422242	5.25	MS	139.	GK-3266	6.0	MS	172.	KML-102	5.0	MS
105.	KMH-422249	6.0	MS	140.	GK-3255	6.25	MS	173.	KML-28	5.75	MS
106.	KMH-422255	6.5	MS					174.	KML-107	4.25	MR
107.	KMH-422271	7.25	S	141.	KNMH-141	5.25	MS	175.	KML-129	6.5	MS
108.	KMH-422260	5.25	MS	142.	KNMH-131	5.0	MR	176.	KML-113	6.75	MS
109.	KMH-422262	5.75	MS	Sl. No.	Germplasms	Scale mean value	Reac-tion	177.	KML-99	6.0	MS
110.	KMH-422269	6.0	MS	143.	KML-74	6.0	MS	178.	KML-25	5.0	MR
111.	KMH-422270	6.0	MS	144.	KML-76	6.5	MS	179.	KML-112	5.5	MS
112.	KMH-422271	6.5	MS	145.	KML-91	6.25	MS	180.	KML-146	6.25	MR
113.	KMH-422283	6.0	MS	146.	KML-43	7.5	MS	181.	KML-65	3.75	MS
114.	KMH-422284	5.75	MS	147.	KML-155	5.25	MS	182.	KML-115	7.5	MS
115.	KMH-422285	6.75	MS	148.	KML-103	6.75	S	183.	KML-114	4.5	MR
116.	KMH-422286	6.0	MS	149.	KML-117	6.0	MS	184.	KML-143	5.75	S
117.	KMH-422290	6.25	MS	150.	KML-30	5.5	MS	185.	KML-118	4.25	MR
118.	KMH-422231	5.75	MS	151.	KML-67	6.0	MS	186.	KML-111	5.25	MS
119.	KMH-422470	6.0	MS	152.	KML-137	6.5	MS	187.	KML-147	6.25	MR
120.	DHM-117	6.5	MS	153.	KML-47	6.0	MS	188.	KML-104	6.25	MS
121.	Syngenta -7074	6.5	MS	154.	KML-129	6.0	MS	189.	KML-13	6.25	MS
122.	NK7702	4.5	MR	155.	KML-95	4.5	MS	190.	KML-141	5.25	MS
123.	DHM-121	5.0	MR	156.	KML-109	5.0	MS	191.	KML-39	2.25	MS
124.	K-50	8.0	S	157.	KML-5	3.25	MR	192.	KML-19	5.75	MS
125.	DKC-9178	3.5	MR	158.	KML-26	5.5	MR	193.	KML-49	4.75	R
126.	DKC-9247	5.25	MS	159.	KML-15	6.25	MR	Check	Kaveri-50	8.20	MS
127.	DKC-9233	5.0	MR	160.	KML-126	5.5	MS				
128.	P-3401	3.5	MR	161.	KML-106	6.0	MS				
129.	P-3302	4.0	MR	162.	KML-89	6.5	MS				
130.	S-6668	6.0	MS	163.	KML-154	5.25	MS				
131.	NK-30	6.0	MS	164.	KML-24	5.75	MS				
132.	Brevent8135	5.5	MS	165.	KML-134	5.25	MS				
133.	PAC-751	5.75	MS	166.	KML-152	7.5	MS				
134.	PAC-751 elite	4.25	MR	167.	KML-101	6.25	MS				
135.	GK-3264	5.25	MS	168.	KML-105	6.0	S				
136.	GK-3268	5.75	MS	169.	KML-89	5.75	MS				
137.	GK-3263	6.5	MS	170.	KML-142	5.5	MS				

moniliforme and *M. phaseolina* under sick plot accompanied by toothpick inoculation method and studied the gene action contributing for stalk rot resistance. They reported that predominant additive gene effect inferring towards resistance to these diseases.

Out of 12, only three cultivars (FH-1228, FH-1025 and FH-1225) were scored as a moderately resistant to charcoal rot disease (Shoaib et al., 2019).

Krishna et al. (2019) screened seventeen lines against charcoal stalk rot of maize in two locations. The results indicated that the disease reaction ranged from 1.3 to 6.5 at Delhi and 2.5 to 7.7 at Ludhiana. Nine inbreds namely DQL 2008-1, DQL 2009, DQL 2010, DQL 2015, DQL 2028, DQL 2031, DQL 2034, DQL 2039 and DQL2071 were found moderately resistant with sc ore between 3.1 and 6 at both locations.

Kalpana et al. (2022) also reported the similar work on maize against *Fusarium verticilliodes* and identified eight genotypes AH1625, BAU-MH-18-2, GGMH-114, GK 3207, CMH-12-686, CAH 1511, ADH 1619 and FQH-148 with stable resistance. Total of 36 elite inbreds were screened under field conditions of disease screening during *kharif,* 2020, 2021, *rabi,* 2020-21 and 2021-22 and identified six inbreds namely BML-100, BML-101, BML-102, BML-103, BML-106 and BML-108 were found resistance to charcoal rot of maize with disease score less than 3 on 1-9 scale (Mallaiah et al.,2023).

Out of 10 hybrids,only three (AS1820, AS1822, and P3707) hybrids noticed the lowest average incidence of charcoal rot and the highest yields in maize (Costa et al., 2023.)

Out of 37 maize genotypes, one inbred line (PFSR 135), three testers (CML 286, CML 451, and BML 7) and eight hybrids (PFSR 51 × BML 6, PFSR 132 × CML 286, PFSR 29×CML 451, PFSR 70×BML 6, PFSR 76×CML 286, PFSR 135×CML 286, PFSR 70×BML 7, PFSR 76×BML 7) exhibited resistant reaction to thecharcoal rot disease (Laxmi Sravya et al., 2023)

4. CONCLUSION

Among 469 entries, only two lines KMH-42283 and KML-39 were resistant. Whereas,57 entries namely KML-79, KML-52, KML-54, KML-10, KML-75, KML-34, KML-72, KML-80, KML-29, KML-61, KML-1,KML-5, KMH-422730, KMH-422758, KMH-422752, KMH-422753, KMH-42229, KMH-422788, KMH-422777, KMH-42284, KMH-42247, KMH-422972, KMH-422838, KMH-421353,KML-95, KML-109, KML-5, KML-102, KML-107, KML-25, KML-65, KML-114, KML-118, KML-49, KMH-422302, KMH-422307, KMH-422475, KMH-422325, KMH-422333, KMH-422381, KMH-422382, KMH-422383, KMH-422384, KMH-422391, KMH-422397, KMH-422590, KMH-422480, KMH-422518,NK-7702,DHM-121,DKC-9178,DKC-9233,P-3401,P-3302,KNMH-131,PAC-751elite and GK-3237 were moderately resistant. Disease reaction varied from resistant to moderately susceptible against *Macrophomina phaseolina* among entries.

5. REFERENCES

Anonymous, 2014. Annual Report of AICRP Maize Pathology, Udaipur center. Available fromhttps://aicrpmaize.icar.gov.in. Accessed on 22nd November 2014.

Anonymous, 2022. Agricultural statistics at a Glance. Government of India Ministry ofAgriculture and Farmers Welfare Department of Agriculture & Farmers Welfare Economics and Statistics Division. 38, 39–78. Available from www.agricoop.nic.in and http://desagri.gov.in. Accessed on 20th December 2022.

Anonymous, 2012. Inoculation methods and disease rating scales for maize diseases. directorate of maize research, New Delhi. Available on https://krishi.icar.gov.in/jspui/bitstream and Accessed on 10th October 2012.

Clark, R.L., Foley, D.C., 1985. Stalk rot resistance and strength of maize stalk from the plant Introduction collection. Plant Disease 69, 419–422.

Costa, R.V., Souza, M.R., Rodrigo Estevam, E.M., Cota, V., Silva, F.R., 2023. Incidence of charcoal rot (*Macrophomina phaseolina*) in maize hybrids in different environments during off-season.Revista Brasileira de Milho e Sorgo, v.22, e1319.

Desai, S., Hegde, R.K., Desai, S.A., 1991. Preliminary survey of incidence of stalk rot complex of maize in two districts of Karnataka. Indian Phytopathology 43, 575–576.

Gopala, A., Gogoi, R., Hooda, K.S., Rai, S.N., Kumar, A., Hossain, F., 2016. Rapid screening technique for evaluation of maize genotypes against stalk rot complex caused by *Macrophomina phaseolina* and *Fusarium verticilloides*. Indian Journal of Agricultural Sciences 86(8), 1024–1030.

Harlapur, S.I., Wali, M.C., Prashan, M., Shakuntala, N.M., 2002. Assessment of yield losses inmaize due to charcoal rot in Ghataprabha Left Bank Canal (GLBC) command area of Karnataka. Karnataka Journal of Agricultural Science 15, 590–591.

Hooda, K.S., 2012. Identifying sources of multiple disease resistance in maize. Maize Journal 1, 82–84.

Hooda, K.S., Khokhar, M.K., Sekhar, J.C., Bagaria, P.K., Sharma, S.S., Kaur, H., Gogoi, R., Reddy, R., 2017. Identification of resistance sources against Post flowering stalk rot in maize. Indian Phytopathology

70(4), 432–439.

Hooda, K.S., Bagaria, P.K., Khokhar, M., Kaur, H., Rakshit, S., 2018. Mass screening techniques for resistance to maize diseases.PAU Campus, Ludhiana, 70–77.

Kalpana, Y., Sharma, S.S., Sarita, Sharma, A.K., Gurjar, S.K., 2022. Source of stable resistance against post flowering stalk rot of maize (*Zea mays* L.) in various maturity groups and speciality corn in subtropical region of India. Biological forum-An International Journal 14(2), 481–485.

Kaur, H., Malhi, N.S., Chawla, J.S., 2010. Evaluation of maize genotypes for resistance to maydis leaf blight and charcoal rot under artificial epiphytotic conditions. Indian Phytopathology 63, 21–2.

Krishna, K.M., Chikkappa, G.K., Manjulatha, G., 2019. Components of genetic variation for *Macrophomina phaseolona* resistance in maize. Journal of Research ANGRAU 41, 12–15.

Kumar, M., Lal, H.C., Johan, M., 1998. Assessment of yield loss due to post flowering stalk rots in maize. Journal of Applied Biology 8, 90–92.

Laxmi Sravya, T.G., Seshu, T., Yella Goud, Y., Nagesh Kumar, M.V., 2023. Screening of some maize cultivars for charcoal rot in northern region of Telangana, India. International Journal of Plant & Soil Science 35(19), 1542–1548.

Nagy, E., Cabulea, I., 1996. Breeding maize for tolerance to Fusarium stalk and ear rot stress. Romanian Agricultural Research 5(6), 45–52.

Mallaiah, B., Bhadru, D., Nagesh Kumar, M.V., Vani Sree, K., Srilatha, Siva Lakshimi, Y., Lavakumar Reddy, M., Neelam, S., Sekar, J.C., 2023. Identification of stable resistant genotypes against charcoal rot of maize (*Zea mays* L.) incited by *Macrophomina phaseolina* (Tassi) Goid. Biological Forum–An International Journal 15(6), 122–125.

Mir, Z.R., Singha, P.K., Zaidi, P.H., Vinayan, M.T., Sharma, S.S., Krishna, M.K., Vemula, A., Rathore, A., Nair, S.K., 2018. Genetic analysis of resistance to post flowering stalk rot in tropical germplasm of maize (*Zea mays* L.). Crop Protection 106, 42–49.

Payak, M.M., Sharma, R.C., 1983. Disease rating scales in maize in India. (In) Techniques of scoring for resistance to diseasesofmaize in India. All IndiaCo-ordinated Maize Improvement Project, IARI, New Delhi, 1–4.

Payak, M.M., Sharma, R.C., 1985. Maize diseases and approaches to their Management in India. Tropical Pest Management 31, 302–310.

Shankar Lingam, S., Venkatesh, S., 2005. New source of resistance to post flowering rot in maize. Indian Journal of Plant Protection 33(1), 99–101.

Sharma, R.C., De Leon, C., Payak, M.M., 1993. Diseases of maize in south and South-East Asia: problems and progress. Crop Protection 12, 414–422.

Shekhar, M., Kumar, S., Sharma, R.C., Singh, R., 2010. Sources of resistance against post- flowering stalk rot of maize. Archives of Phytopathology and Plant Protection 43, 259–263.

Shoaib, A., Ahmed, J., Akhtar, S., Awan, Z.A., 2019. Comparative resistance of maize cultivars to charcoal rot disease. Pakistan Journal of Science 71(4), 202–207.