

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

## 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, 492 entries 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-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 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 8.0 disease rating and rated as susceptible during kharif, 2022.

## Keywords

Screening, genotypes, hybrids, toothpick method of inoculation, disease rating scale, charcoal rot disease, 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 3,349 kg/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" (Anonymous, 2022). 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 (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% (Harlapure *et al.*, 2002), 42 to 100% (Laxmi Sravya *et al.*, 2023) and in

recent years yield reduction has been reported to be as high as 22.3 to 63.5% (AICRP, 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 stalk rot resistant germplasm in India (Shekhar *et al.*, 2010, Hooda *et al.*, 2012) and abroad (Clark and Foley 1985). In India, artificial epiphytotic condition for stalk rot disease is created by inoculating the plants in the field just after flowering mainly by toothpick method of inoculation (Anon. 2012).

## 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 February, 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 (Hooda *et al.*, 2018). The test genotypes were planted in 2 rows of 3m length each with a plant spacing of 60×20 square centimeters.

Screening reinforced with artificial inoculation using tooth pick method is effective in supplementing the disease sick plot technique of screening against charcoal rot. The tooth pick inoculation method 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 (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 inoculum were inserted into the hole that effectively sealed the hole to prevent drying of the inoculum.

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), viz., Resistant (R), Moderately Resistant (MR), Moderately Susceptible (MS) and Susceptible (S) reaction. Randomised block design method was used for analysis.

**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 discoloration at the site of inoculation      | Resistant<br>(Score: $\leq 3.0$ )          |
| 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 internode is discoloured                    | Moderately resistant<br>(Score: 3.1-5.0)   |
| 5                    | Less than 50% discoloration of the adjacent internode                 | Moderately susceptible<br>(Score: 5.1-7.0) |
| 6                    | More than 50% discoloration of the adjacent internode                 |  |
| 7                    | Discoloration of three internodes                                     |  |
| 8                    | Discoloration of four internodes                                      | Susceptible (Score: $\geq 7.0$ )           |
| 9                    | Discoloration 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 at the end.

### 3.0 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 lines viz., 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, 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 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 germplasm was 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, 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, 133 hybrids were found moderately susceptible and 14 hybrids were found susceptible during kharif-2022 (Table 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-1 were identified to be resistant to PFSR (*Cephalosporium maydis*, *Fusarium moniliforme* and *Macrophomina phaseolina*) (Shekharet 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., H62, 14933, H109, P503, P408, E684, P364, E613, P345, 18855 were moderately resistant in field (Gopala et al., 2016).

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', 'Sweetcorn', 'Insec1(k4)', 'NC392', 'DMSC1', 'DMSC36', 'DMSC-37-3', 'Gen1858', 'HKIPC4B', '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', 'HKI226', 'HKI1040-5', 'HKI1094-11-7', 'HKI1040-5', 'HKI1094-WG', 'CML451(P2)', 'ESM-11-3', 'PFSR/51016-1', 'Gen6033', 'Hyd05r/2-1', 'Hyd05R/13-2', 'Hyd05204-1', 'LM5', 'LM6', 'LM11', 'LM12', 'LM15', 'LM15', 'LM16', 'V341-1', 'V351-1', 'V351-2', 'CM114', 'CM123', 'CM132', 'CM144', 'CM149', 'CM500', 'HKIC78', 'HKI141-1', 'HKI141-2', 'HKIC323', 'HKI1352-5-8-9', 'CML141', 'CML269', 'CML384', 'HKI16-4-(1-3)-2', 'HKI164-7-4

ER-3', 'HKI164-7-4', 'HKI164-7-4-2', 'HKI164-7-2', 'HKI193-2-2', 'HKI1932-2-1', 'HKI193-2-2-4', 'HKI193-1', 'CML165', 'CML167', 'CML171', 'CML172', 'HKI MBR-139', 'HKIMBR-139-2', 'DMR QPM-03-104', 'DMR QPM-58-26', 'CML158', 'CL-QRCYQ47', 'CLQRCYQ-47-B', 'CLQ-RCYQ30', 'CLQ-RCYQ36', 'CLQ-RCYQ40', 'CML451Q', 'DMRQPM58', 'HKI3322', 'DMHOC 4', 'Temp.Hoc15', 'Tem.TropHighoilQPM', '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', 'CML33', 'JCY3-7-1-2-1-'B-2-3-2-1-2-1', 'SW-93D-313-23-POP.49-S4-1', 'JCY3-7-1-2-1-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', 'JCY2-2-4-1-1-1-3-1-3-1', '42050-1-1-2-1-3', 'JCY3-7-1-2-1-B-1-1-2-3-1-1', 'CM117-3-4-1-2-5-2', 'JCY3-7-1-2-2-1-3-1-1-2-7-1-1-1', 'LM13', 'CM117-3-4-1-2-2-3', 'JCY3-7-1-2-1-B-2-1-2-1', 'SW93D-313-23-POP-.49-S4-1-3-1', 'CML 44', 'JCY3-7-1-2-1-b-2-3-2-3-1-1-1', 'LTP1', 'LTP4') were found resistant against post-flowering stalk rots (Hooda *et al.*, 2012).

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  $\leq 3.0$  were identified PFSR disease resistance sources for different maize agro ecologies in India (Hooda *et al.*, 2017).

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

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.

Kalpna *et al.*, 2022, also reported on maize against *Fusarium verticillioides* and identifies eight genotypes AH1625, BAU-MH-18-2, GGMH-114, GK3207, CMH-12-686, CAH1511, ADH1619 and FQH-148 with stable resistance.

37 maize genotypes against the *M.phaseolina* pathogen, the inbred line PFSR 135 and three testers viz., CML286, CML4541, and BML7 were noticed resistant to the charcoal rot disease (Laxmi Sravya *et al.*, 2023).

## CONCLUSION:

In order to identify 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, KML-78, 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-202andB-8135werefoundmoderatelyresistanttocharcoalrot disease. **Asa result, most of the genotypes exhibited disease reaction varying from resistant (score 3) to moderately susceptible(score7) against *Macrophominaphaseolina*.**

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**Table2:**DiseaseratingscaleofMaizeentries tocharcoalrot diseaseinrabi2021-2022

| Slno. | Germplasms | Charcoal rot<br>disease scale<br>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                      |
| <b>Sno.</b> | <b>Hybrids</b> | <b>Charcoal rot<br/>disease scale<br/>mean</b> | <b>Disease reaction</b> |
| 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:ModeratelyResistant,MS:ModeratelySusceptible,S:Susceptible. Table 3:

Disease rating scale of Maize entries to charcoal rot disease in kharif-2022

| <b>Sln.</b> | <b>Germplasms</b> | <b>Charcoalrot disease scale mean</b> | <b>Disease reaction</b> |
|-------------|-------------------|---------------------------------------|-------------------------|
| 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                      |
| <b>Slno.</b> | <b>Hybrids</b> | <b>Charcoalrot disease scale mean</b> | <b>Disease reaction</b> |
| 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 | KNMH-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-751elite  | 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:ModeratelyResistant,MS:Moderately Susceptible,S:Susceptible.