The Pharma Innovation Journal 2023; 12(5): 1311-1314

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(5): 1311-1314

www.thepharmajournal.com
Received: 15-02-2023
Accepted: 18-03-2023

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# Screening of maize germplasm against maize rust under natural field conditions in mid hill region of Jammu

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**Abstract**
Maize (corn) is one of the most widely grown cereal crops globally and one of important cereal crop after wheat and paddy in India. The mid hill region of Jammu *viz*., Rajouri and Poonch are agro- climatically intermediate to temperate region where maize is grown as sole crop or intercropped with common bean in Jammu and Kashmir. Among various biotic & abiotic stresses, fungal diseases of maize cause significant economic damage by reducing maize yields and by increasing input costs for disease management. The most sustainable control of maize diseases is through the release and planting of maize cultivars with durable disease resistance. Screening of the 128 maize germplasm under natural field conditions, 9 are highly resistant, 19 are resistant, 37 are moderately resistant, 50 are moderately susceptible and 13 are highly susceptible. The following germplasm *viz*., IIMRNH-2015-1, IIMRNH-2015-3, IMH-1525, IMH-1527, Ganga-7, Rajendra hybrid makka-2, Vijay, BGMH-1 and BGMH-2 are reported to be highly resistant. The maize rust resistant source comes in a variety of levels of resistance. Incorporating these resources into a resistance breeding programme could aid in the production of high-yielding rust resistant maize cultivars.

**Keywords:** Biotic stress, germplasm maize, resistant and screening

## Introduction
Maize (*Zea mays* L.) is the third important cereal crop of world after rice and wheat and ranks first with respect to production and productivity with wide adaptability to diverse agroclimatic condition of world (Muiru *et al*., 2010; Keya and Rubaihayo, 2013) [8, 6]. The crop produces a high yield per unit of land, making it an important crop for ensuring consumer food availability and security (Mboya *et al*., 2011) [7]. Maize will become the most productive crop by 2025, while demand for maize in developing countries will double by 2050, (Rosegrant *et al*., 2008) [11].

Globally maize is cultivated over an area of 193.7 million ha with annual production of about 1147.7 million MT and average productivity of 5.75 tons per ha (FAOSTAT, 2020) [2]. In India maize is cultivated over an area of about 9.2 million ha with annual production of 27.8 million MT and average productivity of 3.2 tons per ha (DACNET, 2020) [1].

The mid hill region of Jammu *viz*., Rajouri and Poonch are agro-climatically intermediate to temperate region where maize is grown as sole crop or intercropped with common bean. In Jammu and Kashmir, maize is second most important crop after rice, cultivated on an area of 295.2 thousand ha with annual production of 5411 thousand quintals and average productivity of 18.3 quintals per ha (J&K Envis Newsletter, 2017) [5].

Maize crop in India are attacked by 18 foliar diseases. The maize rust is one of the most important disease that cause a yield loss of 12 to 61 percent. The disease occurs in the early stages of crop development and has a long-term impact on crop growth and yield potential. Rust symptoms on leaves include round to elongate dark brown pustules (Uredinia) distributed across both leaf surfaces, giving the leaf a rusty appearance (Hooker, 1985) [4].

The most cost-efficient, effective and practical means of avoiding crop output loss due to diseases is to employ varieties with genetic resistance (Ribeiro *et al*., 2016) [10]. Since 20 hypersensitive resistance (Rp) genes have been identified against maize rust in corn germplasm, partial or hypersensitive resistance can be used to manage it (Hooker, 1969) [3]. The Rp3 genes give resistance to maize rust in maize. It is feasible to find numerous candidate genes and Quantitative Trait Loci (QTL) that are strongly related with resistance to maize rust

(Zheng *et al*., 2018) [13].

## Materials & Methods

Maize germplasm set consisting of indigenous lines in advanced stage of maintenance along with popular commercial cultivars available at Regional Agricultural Research Station, Rajouri were screened under field conditions during *Kharif* 2020. The rust infested maize leaves collected during survey were macerated thoroughly and dipped in sterilized distilled water. The urediospores thus obtained were kept in freezer at 5-7 °C and used for inoculation purposes.

Using a glass atomizer, two to three drops of tweens-20 were added per litre of spore suspension and the suspension was sprayed thoroughly over the plants at three to four leaves stage during the evening hours. To get a high disease pressure, the inoculation was performed twice. 1 to 9 evaluating scale was used to record disease reaction (Paterniani *et al*., 2000) [9]. This screening revealed relatively resistant lines from varied genetic backgrounds, as well as genotypes that were highly susceptible. Percent disease severity (PDS) was calculated using the following formula:

$$\text{Percent Disease Severity} = \frac{\text{Sum of numerical ratings}}{\text{Total No.of leaves observed x maximum grade}} \text{ X } 100$$

**Table 1:** Disease rating Scale on the basis of PDS the varieties were classified as resistant (R), moderately resistant (MR), moderately susceptible (MS) and susceptible (S)

| Score | Disease Severity (%) | Disease reaction |
|---|---|---|
| 1 | <11.11 | Highly Resistant |
| 2 | 11.11-22.22 | Resistant |
| 3 | 22.22-33.33 | Moderately Resistant |
| 4 | 33.33-44.44 | |
| 5 | 44.44-55.55 | Moderately susceptible |
| 6 | 55.55-66.66 | |
| 7 | 66.66-77.77 | Susceptible |
| 8 | 77.77-88.88 | |
| 9 | 88.88-99.99 | |

**Table 2:** List of Germplasm used for the screening of maize rust

| S. No. | Germplasm | S. No. | Germplasm |
|---|---|---|---|
| 1 | Buland | 37 | HKI-161 |
| 2 | Sheetal | 38 | HKI-163 |
| 3 | Allrounder | 39 | HKI-193-1 |
| 4 | HHM-1 | 40 | HKI-193-2 |
| 5 | HHM-2 | 41 | DAS-NH-306 |
| 6 | HHM-129 | 42 | IIMRNH-2015-1 |
| 7 | CMH11-620 | 43 | IIMRNH-2015-2 |
| 8 | PEHM-1 | 44 | IIMRNH-2015-3 |
| 9 | PEHM-2 | 45 | IIMRNH-2015-4 |
| 10 | Prabal | 46 | IIMRNH-2015-5 |
| 11 | Parkash | 47 | IMH-1525 |
| 12 | APH-1 | 48 | IMH-1527 |
| 13 | APH-3 | 49 | IMH-1535 |
| 14 | APH-4 | 50 | BM-1312 |
| 15 | APQH-1 | 51 | BM-1326 |
| 16 | APQH-8 | 52 | BM-1378 |
| 17 | AH-8067 | 53 | BM-1441 |
| 18 | AH-8106 | 54 | BM-1466 |
| 19 | AH-8727 | 55 | Deccan hybrid |
| 20 | AH-1619 | 56 | Kaveri-235 |
| 21 | AH-8628 | 57 | Gold |
| 22 | AH-8741 | 58 | Ganga safed-2 |
| 23 | AH-8798 | 59 | Ganga-4 |
| 24 | AH-4164 | 60 | Ganga-7 |
| 25 | AH-4152 | 61 | Ganga-11 |
| 26 | AH-4654 | 62 | Hi-Starch |
| 27 | AH-4142 | 63 | Himalayan-123 |
| 28 | AH-1625 | 64 | Paras |
| 29 | AH-4167 | 65 | PMH-12 |
| 30 | AH-4272 | 66 | Rajendra hybrid makka-2 |
| 31 | AH-4139 | 67 | Amber |
| 32 | AH-3001 | 68 | Mahabeej-1302 |
| 33 | AH-1634 | 69 | Vijay |
| 34 | HKI-323 | 70 | Jawahar |
| 35 | HKI-1105 | 71 | Kisan |
| 36 | HKI-1128 | 72 | Swarna |
| 73 | Sona | 109 | NMH-109 |
| 74 | Vikram | 110 | DK-701 |
| 75 | Muskan | 111 | Amar-606 |
| 76 | Shakti | 112 | PMH-3 |
| 77 | Rattan | 113 | DHM-105 |
| 78 | Protina | 114 | RCRMH-1 |
| 79 | Pratap | 115 | NK-61 |

| | | | |
|---|---|---|---|
| 80 | Aget-76 | 116 | GK-3090 |
| 81 | Navjot | 117 | GK-30R77 |
| 82 | Tarun | 118 | Pro-311 |
| 83 | Kanchan | 119 | Bio-9681 |
| 84 | Shweta | 120 | Bio-9637-C |
| 85 | DK-984 | 121 | BGMH-1 |
| 86 | C-6 | 122 | BGMH-2 |
| 87 | C-8 | 123 | LMH-715 |
| 88 | C-14 | 124 | LMH-815 |
| 89 | C-15 | 125 | NK-6240 |
| 90 | HM-10 | 126 | NK-61 |
| 91 | Vivek-33 | 127 | NK-121 |
| 92 | Parkash | 128 | NK-7305 |
| 93 | JKMH-1701 | | |
| 94 | X-3342 | | |
| 95 | Vivek-17 | | |
| 96 | Vivek-21 | | |
| 97 | Udaipur | | |
| 98 | PEEH-5 | | |
| 99 | Kaveri-225 | | |
| 100 | PAU-352 | | |
| 101 | PEH-3 | | |
| 102 | Parkash | | |
| 103 | X-3342 | | |
| 104 | KNMH-4501 | | |
| 105 | Kiran | | |
| 106 | HM-4 | | |
| 107 | HM-8 | | |
| 108 | CP-808 | | |

**Screening of maize germplasm**

To manage the disease in the long run, continuous efforts to find resistant sources and use them in resistance breeding programmes are required. Screening was carried out under naturally occurring fields condition during *Kharif* 2020 to evaluate maize germplasm set consisting of indigenous Lines in advance stage of maintenance, available at Regional Agricultural Research Station, Rajouri, SKAUST-Jammu.

The lines were evaluated based on 1-9 disease rating scale (Paterniani *et al*., 2000) [9]. The result of various lines is presented in (Table 3 and plate 1). Significant variation in disease severity for maize rust were observed in various germplam. Out of the 128 germplasm evaluated only 09 germplasm found highly resistant *viz*., IIMRNH-2015-1, IIMRNH-2015-2, IMH-1525, IMH-1527, Ganga-7, Rajendra hybrid makka-2,Vijay, BGMH-1 and BGMH-2. 19 germplasm were identified as resistant, 37 found moderately resistant, 50 moderately susceptible and 13 were susceptible.

**Table 3:** Disease reaction of different germplasm against maize rust under field conditions during *Kharif*- 2020

| Disease reaction | No. of germplasm | Germplasm |
|---|---|---|
| Highly Resistant | 09 | IIMRNH-2015-1, IIMRNH-2015-3, IMH-1525, IMH-1527, Ganga-7, Rajendra hybrid makka-2, Vijay, BGMH-1 and BGMH-2. |
| Resistant | 19 | Buland, HHM-1, HHM-2, CMH11-620, IMH- 1535, BM-1312, BM-1326, BM-1441, Gold, Ganga-11, Hi-starch, Himalayan-123, Mahabeej- 1302, Jawahar, Kisan, Parkash, X-3342, Nk-6240 and Ganga 4. |
| Moderately Resistant | 37 | Sheetal, Allrounder, HHM-129, Prabal, Parkash, AH-8106, HKI-161, HKI-163, IIMRNH-2015-2, IIMRNH-2015-4, IIMRNH-2015-5, BM-1378, BM-1466, Kaveri-235, Ganga safed-2, Paras, Amber, Swarna, Sona, Vikram, Muskan, Shakti, Aget-76, Navjot, DK-9 C-6, C-15, PEH-3, Parkash, CP-808, PMH-3, GK-3090, GK-30R77, NK-121, NK-61, NK-7305 and C-14. |
| Moderately Susceptible | 50 | PEHM-1, PEHM-2, APH-1, APH-3, APH-4, APQH-1, AH-8067, AH-8628, AH-8741, AH- 3001, AH-8727, AH-1619, AH-8798, AH-4164, AH-4152, AH-4654, AH-4142, AH-1625, AH- 4139, AH-1634, HKI-323, HKI-1105, HKI-1128, HKI-193-1, HKI-193-2, DAS-MH-306, PMH- 12,Rattan, Protina, Pratap, Tarun, Kanchan, Shweta, C-8, Vivek-33, JKMH-1701, Vivek-17, Vivek-21, PEEH-5, PAU-352, X-3342, HM-4, HM-8, RCRMH-1, NK-61, Pro-311, Bio-9681, Bio-9637-C, LMH-715 and LMH-815. |
| Susceptible | 13 | APQH-8, AH-4167, AH-4272, Deccan hybrid, HM-10, Udaipur, Kaveri-225, KNMH-4501, Kiran, NMH-109, DK-701, Amar-606 and DMH- 105. |

**Plate 1:** Screening of germplasm against maize rust under naturally occurring field conditions

## Discussion

Fields screening studies indicated that there was a different disease response of maize germplasm to *Puccinia sorghi*. The present study revealed that out of 128 germplasm tested, 9 germplasm show high level of resistant (HR) in 1 to 9 evaluation scale *viz*., IIMRNH-2015-1, IIMRNH-2015-2, IMH-1525, IMH-1527, Ganga-7, Rajendra hybrid makka-2, Vijay, BGMH-1 and BGMH-2, 19 germplasm show resistant reaction, 37 show moderately resistant reaction, 50 show moderately susceptible reaction and remaining 13 show susceptible reaction. This suggests that the disease progression was efficient, and that the categorization of materials into distinct classes was appropriate. As a result of the findings, it can be concluded that the found highly resistant and resistant lines have excellent potential for resistance to *Puccinia sorghi*, which causes maize rust in maize, and can be utilized to generate inbreds and composites in future disease-resistant breeding programmes. Genes for resistance to *Puccinia sorghi* from many parts of the world are being transferred to the susceptible inbreds by back crossing to develop nearly isogenic lines with different genes for resistance.

Through comprehensive annotation, nine candidate's genes for resistance to maize rust linked loci were found on chromosomes 1, 5, 6, 8 and 10 (Zheng *et al*., 2018) [13]. Thirty-three maize lines were shown to be resistant to the maize rust disease (11 quality proteins maize and 22 normal maize lines). However, studies of various worker also reported the same, in Bihar, Ganga 4 germplasm show resistance to *Puccinia sorghi*, while PBW-500 and HW-2004 germplasm are free of both rusts. However, VL-822 and VL-829 germplasm show resistance to both rusts (Singh, 1998) [12].

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