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Screening of sorghum (*Sorghum bicolor* (L.) Moench) genotypes against sorghum rust caused by *Puccinia purpurea* Cooke

GR Vishwas Gowda, KB Yadahalli, PV Patil, NG Hanamaratti and TT Bandiwaddar

Abstract
Sorghum (*Sorghum bicolor*) is an important cereal crop grown in semiarid, subtropical, tropical and temperate regions and ranks fifth in worldwide cereal crop production. Rust of sorghum (*P. purpurea*) is an important emerging disease in most of the sorghum growing areas of the world, which can increase the susceptibility to other pathogens. Host plant resistance plays a pivotal role in disease management within crop improvement programs. Employing resistant cultivars stands out as a straightforward, cost-effective, and highly efficient strategy. Out of 305 sorghum genotypes screened, none of the genotypes showed highly resistant reaction or immune reaction, only 1 showed resistant reaction (E-4), 16 genotypes showed moderately resistant reaction (ICSV 745, SVD 1327R, KDSL 20, ICSV 17003, CB 33, 401B, CSV 20, SVD 1221R, SVD 1549R, SVD 1564R, SVD 1565R, SVD 1356R, SVD 1423R, ICSR 13042, EP 65, Dambal local), 30 showed moderately susceptible, 170 recorded susceptible reactions and remaining 88 were found highly susceptible reaction under natural epiphytotic condition. Further this data can be used to develop resistant varieties and hybrids in sorghum to rust disease.

Keywords: Screening, Cooke, sorghum, *Puccinia purpurea*, *Sorghum bicolor* L.

1. Introduction
Sorghum (*Sorghum bicolor* (L.) Moench) is a plant belonging to the family of grasses (Poaceae). It is a C4 grass that diverged from maize around 15 million years ago, is the fifth most important cereal crop in terms of production and planting area globally. All crops have originated and evolved from wild relatives, and Sorghum, a native African cereal and cultivated sorghums of today arose from the wild members of *S. bicolor* subsp. *verticilliflorum* (Dogget, 1988) [5]. The origin and early domestication of sorghum is hypothesized to have taken place in northeastern Africa or at the Egyptian–Sudanese border around 5000–8000 years ago (Mann *et al*., 1983) [6]. It is not only one of the most important carbohydrate-rich crops and a key staple food crop for millions of semi-arid tropics residents (Asia and Africa), but it is also known as the "King of Millets" and it has been increasingly used as feed over the years in many developed countries as well (Rao *et al*., 2010) [7].
The global sorghum output was lowered by 3.43% when compared to 2021-22 production due to biotic and abiotic variables impacting crop yield (Anon., 2023) [23]. Pests and diseases are major biotic limitations. Sorghum diseases are caused by a variety of pathogenic organisms, including fungus, bacteria, and viruses like downy mildew (*Peronosclerospora sorghi* (W. Weston and Uppal) C.G. Shaw], anthracnose [*Colletotrichum graminicola* (Ces.) G.W. Wilson], charcoal rot [*Macrophomina phaseolina* (Taasi) Goid.], downy mildew, rust (*Puccinia purpurea* Cooke.), grain smut (*Sphacelotheca sorghi* Ehrenb. Ex Link.), loose smut [*Sphacelotheca cruenta* (J.G. Kuhn) Vanky.], head smut [*Sphacelotheca reiliana* (J.G. Kuhn) G.P. Clinton.], long smut [*Sporisorium ehrenbergii* (Kuhner) Vanky.], ergot (*Claviceps sorghi* B.G.P. Kulk.), grain mould (*Fusarium sp., Drechslera sp., Curvularia sp., Alternaria sp., Aspergillus sp.*, and *Phoma sp.*) etc. Among the insect pests, shoot-fly causes substantial losses in late and off-season crops in many growing countries in Asia and Africa. Stem borers are endemic in all sorghum growing areas. Head bugs, shoot-bugs, midges, mites, and sugarcane aphids limit the crop yield in varying intensity.
Sorghum rust caused by *Puccinia purpurea* Cooke. is an important emerging disease in most of the sorghum growing areas of the world and it predispose the plants to other major diseases such as fusarium stalk rots, charcoal rot, and grain moulds (Wang *et al*. 2006) [9].

Leaf rust infects sorghum from the flowering phase to the seed filling phase (White *et al*., 2014; CABI 2023) [11, 3]. Yield reduction due to rust has been reported from 13.1% (White *et al*., 2012) [12]. Host plant resistance plays a pivotal role in disease management within crop improvement programs. Employing resistant cultivars stands out as a straightforward, cost-effective, and highly efficient strategy. Identifying robust resistant sources and subsequently developing varieties or hybrids emerges as a superior approach. Evaluating elite lines and commercial available sorghum genotypes provides information regarding their present performance against the disease, which may be helpful in advising the correct choice of cultivars for cultivations. Thus the objective of this research was to identify resistant sorghum genotypes to *Puccinia purpurea* under natural epiphytotics conditions.

2. Materials and Methods

The experiment was conducted in an augmented design with two replications for the check varieties. Each replication consisted of 305 different test genotypes received from the All India Coordinated sorghum improvement project research station, Main Agricultural Research station (MARS), Dharwad were screened against rust in the field during *rabi* 2021-22 under natural epiphytotic condition at MARS, Dharwad. The experimental plot was 1.0 m × 2.0 m and the seeds were planted with a spacing of 45 cm × 15 cm and nutrients provided as per the package of practices of University of Agricultural Sciences, Dharwad.

Observations were made on 5 plants per each genotype at physiological maturity of the sorghum crop for the disease severity of rust disease on leaves was measured using a score of 0 to 9 scale of Anon (2021) [1] with slight modifications and further the grades were converted to percent disease index (PDI) using the formula given by Wheeler (1969) [10]. Based on their host reaction, genotypes were categorized into highly resistant, resistant, moderately resistant, moderately susceptible, susceptible and highly susceptible Table 1.

$$\text{Percent disease index (PDI)} = \frac{\text{Sum of individual rating}}{\text{No. of leaves examined} \times \text{Maximum disease rating}} \times 100$$

Table 1: Modified Scale used for disease scoring (Anon, 2021)

Disease grade	Description	Reaction
0	No symptoms seen on the leaf and perfectly healthy	Immune or Highly Resistant
1	0.1-5% of the leaf area is affected	Resistant
3	5.1-20% of the leaf area is affected	Moderately resistant
5	20.1-40% of the leaf area is affected	Moderately susceptible
7	40.1-75% of the leaf area is affected	Susceptible
9	>75% of the leaf area is affected	Highly susceptible

3. Results and Discussion

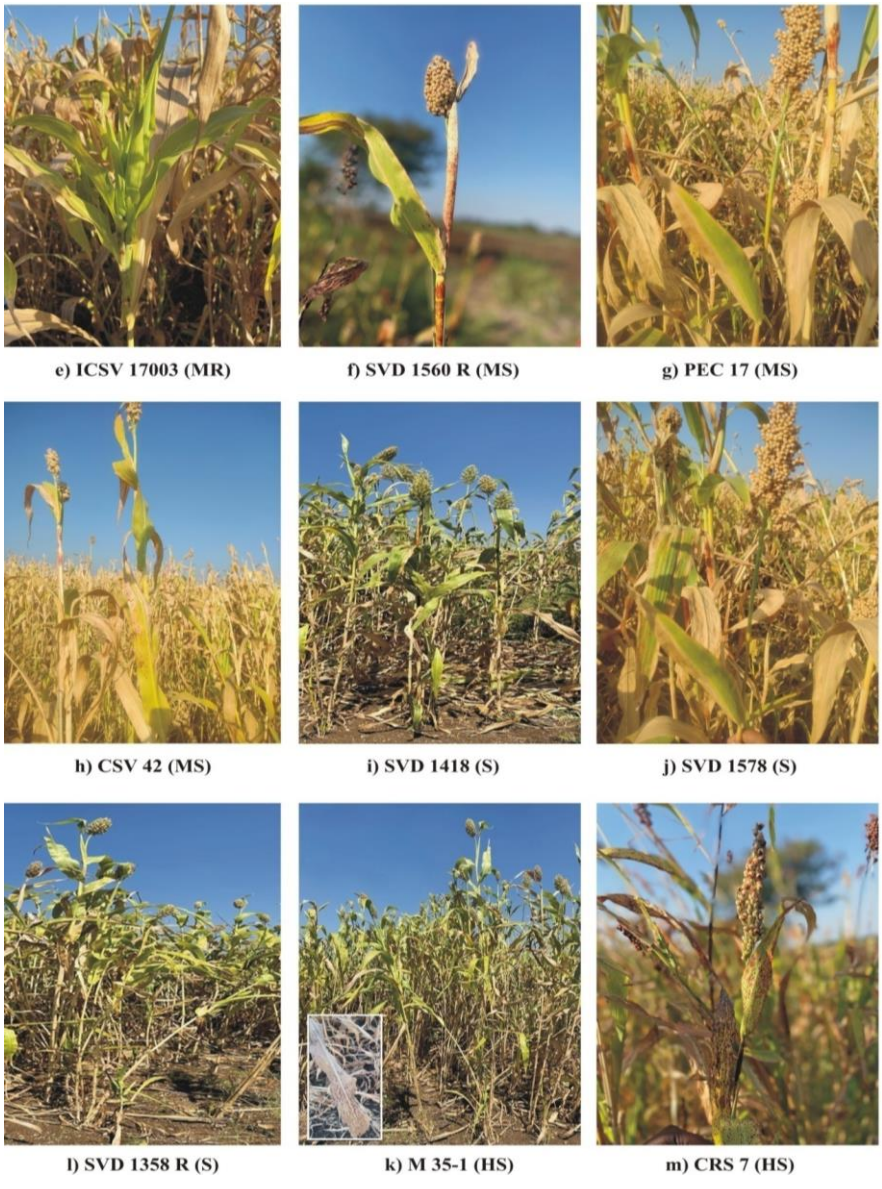
Totally 305 sorghum genotypes received from the All India Coordinated Sorghum Improvement Project Research Station, UAS, Dharwad were screened against rust in the field during *rabi* 2021-22 under natural epiphytotic condition in the field to identify the resistance sources as described in "Material and Methods" and data are presented in Table 2 and Plate 1.

The results revealed that, among the 305 genotypes screened, none showed highly resistant reaction, only 1 showed resistant reaction (E-4), 16 showed moderately resistant reaction (ICSV 745, SVD 1327R, KDSL 20, ICSV 17003, CB 33, 401B, CSV 20, SVD 1221R, SVD 1549R, SVD 1564R, SVD 1565R, SVD 1356R, SVD 1423R, ICSR 13042, EP 65, Dambal local), 30 each showed moderately susceptible (CSV 42, PEC 17, ICSV 93046, DSV 3, 2219B, CSV 31, DSV 2, Somapur local, BJV 44, Tandar local, SVD 1229R, Bidar Kundi Chandaki, CRS 7, SVD 1525R, SVD 1522R, SVD 1430R, SVD 1544R, SVD 1547R, SVD 1548R, SVD 1560R, SVD 1562R, SVD 1354R, SVD 1366R, SVD 1571R, SVD 1264R, EC 28, Bardur local, Bhavihal local, Annikrei local, CSV 29R) 170 shows susceptible reaction and remaining 88 were found highly susceptible reaction under natural epiphytotic condition.

a) General over view of screening plot at 15 DAS

b) E 4 (R) c) 401 B (MR) d) CB 33 (MR)

Plate 1a: Reaction of selected genotypes to rust under natural epiphytotic condition during *rabi* 2021-22.



e) ICSV 17003 (MR) f) SVD 1560 R (MS) g) PEC 17 (MS)

h) CSV 42 (MS) i) SVD 1418 (S) j) SVD 1578 (S)

l) SVD 1358 R (S) k) M 35-1 (HS) m) CRS 7 (HS)

Plate 1b: Reaction of selected genotypes to rust under natural epiphytotic condition during *rabi* 2021-22.

Similar findings were obtained by Sharma *et al.* (2012) [8] conducted experiment to screen against foliar diseases of sorghum during rainy and late rainy seasons. They evaluated 242 germplasm accessions and for rust resistance, screening was done under artificial inoculation in the greenhouse as well as in the field under natural infection. In all, 13 accessions were found resistant (score ≤3 on 1-9 scale) to anthracnose and 27 to leaf blight. Six accessions exhibited resistance to rust (*P. purpurea*) in both the greenhouse and the field. Three mini-core accessions (IS 473, IS 23684, and IS 23521) exhibited resistance to all three diseases and Cuevas *et al.* (2012) [4] evaluated 68 sorghum accessions from the Zimbabwe collection maintained by the USDA-ARS, during two planting seasons in 2011 and 2012 to identify new sources of rust resistance. They concluded that across the two growing seasons, 12 accessions showed resistance, 15 accessions exhibited a moderately susceptible response and 41 accessions showed a susceptible response. PI482787 showed highest resistance to rust across the two growing seasons, while accession PI482795 exhibited the highest rust infection.

Table 2: Screening of sorghum genotypes to rust under field condition

Reaction	Grade	No. of genotypes	Genotypes
Immune or Highly Resistance	0	0	-
Resistant	1	1	E 4
Moderately resistant	3	16	ICSV 745, SVD 1327R, KDSL 20, ICSV 17003, CB 33, 401B, CSV 20, SVD 1221R, SVD 1549R, SVD 1564R, SVD 1565R, SVD 1356R, SVD 1423R, ICSR 13042, EP 65, Dambal local
Moderately susceptible	5	30	CSV 42, PEC 17, ICSV 93046, DSV 3, 2219B, CSV 31, DSV 2, Somapur local, BJV 44, Tandar local, SVD 1229R, Bidar Kundi Chandaki, CRS 7, SVD 1525R, SVD 1522R, SVD 1430R, SVD 1544R, SVD 1547R, SVD 1548R, SVD 1560R, SVD 1562R, SVD 1354R, SVD 1366R, SVD 1571R, SVD 1264R, EC 28, Bardur local, Bhavihal local, Annigeri local, CSV 29R
Susceptible	7	170	SPV 2217, B 35, Swarna, ICSR 13042, CSV 14R, ICSB 433, SPV 2333, DKS 35, SVD 1569R, SVD 1566R, Phule Vasudha, M-148-138, SVD 1449R, Ichangi Bijraj, Gudamalani local, Basavan Moti, ICSR 13025, SVD 1572R, SPV 486, Lokar Giddamaladandi, ICSR 13004, ICSR 13043, ICSR 15001, Lakamapur local, SVD 1574R, Basavan Pad, ICSV 15017, AKS 112, Ichangi-local, SPV 2544, ICSV 16003, ICSV 15020, CSV 17, SPV 2334, SVD 1584R, DSV 4, SVD 1265R, SMJ 1, A 1, SVD 1462R, Karkotti M 35-1, SVD 1573R, SPV 2405, SPV 2468, SVD 1579R, S 35, PMS 20B, ICSB 400, PMS 28B, SPV 2569, SPV 2568, GMN 41, CSV 36, 104B, Kalagunda local, SVD 1418R, RNTN 14-87, SVD 1353R, AKR82B, SVD 1278, Chitapur local, SVD 1364R, Gatti Theni Jola, Yenigar Jola, Kagimoti Jola, Sakkari mukari, Shigali local, Dod mogar, SVD 1407R, Dagdi Solapur, EP 75, EA 9, EP 95, ICSR 89053, SVD 1304R, SVD 1249R, SVD 0807R, CSV 18R, Karda maladandi, Sortgon 2, Sundagatti local, Wadadmani – local, SVD 1155R, Nirmala 259, SVD 0767R, Damngon maladandi, Savadatti local, Murkibhavi local, CSV 26R, Shikandar lakadi, CRS 4, CRS 9, SVD 1224R, SVD 1521R, SVD 1524R, SVD 1530R, SVD 1531R, SVD 1532R, SVD 1533R, SVD 1534R, SVD 1535R, SVD 1537R, SVD 1538R, SVD 1540R, SVD 1541R, SVD 1542R, SVD 1357R, SVD 1545R, SVD 1546R, SVD 1550R, SVD 1556R, SVD 1557R, SVD 1559R, SVD 1561R, SVD 1563R, SVD 1318R, SVD 1349R, SVD 1355R, SVD 1360R, SVD 1364R, SVD 1365R, SVD 1586R, SVD 1367R, SVD 1368R, SVD 1369R, SVD 1405R, SVD 1425R, SVD 1426R, SVD 1431R, SVD 1437R, SVD 1461R, SVD 1329R, SVD 1350R, SVD 1351R, SVD 1357R, SVD 1402R, SVD 1427R, SVD 1428R, SVD 1429R, SVD 1430R, SVD 1433R, SVD 1583R, SVD 1578R, SVD 1401, SVD 1248R, SPV 2034, SVD 0812R, SVD 0810R, SVD 1250R, SVD 1254R, SVD 1582R, EP 92, SVD 1585R, SVD 1296R, SVD 1255R, EP 102, EP 42, EP 80, EP 92, EP 85, DSV 5, EC 8, SVD 1224R, EC 25, Hoshiarpur Vinegar, Ichangi gandu Jola, Matagoni local, Hesrur local, Hattimattur local, Hamagi local
Highly susceptible	9	88	Phule Annuradha, SVD 1581R, CSV 37, RS 585, RSSCV 46, Raosaheb, Parbhani Shakti, ICSR 13039, M 35-1, RSJ 1, ICSV 15016, SVD 1350R, SVD 1252R, SbABM, KDSL 30, Phule Chitra, SVD 1272R, Barsi Zoot, SVD 1568R, EC 19, Dosa Jola, AKJ 1, CSV 22R, Yermal Dukari, EP 94, SVD 1246R, Karjola, SVD 1280, DSV 6, SVD 1290, 1409B, AKMS 14B, SVD 1358R, CSV 27, SVD 1329R, M 31-2B, IS 18551, CSV 39, SVD 0806R, SVD 1212, SVD 1101, DKS-22, SPV 2773, SVD 1419R, SVD 1403R, SPV 2832, SPV 2831, Pinzer Jola, Malari Jola, SSV 74, Kempu Kadabin Jola, Lokari Jola, Billigunda–local, Basavan Pad, Tansulwadi local, SVD 1298R, 5-4-1, Chapalgaon adugodi, Maladandi local, Maladandi malanur, Chappligon local, Chungi maladandi, Nirmala Swarna, Yermal local, Afselpur local, Damngon dagadi, SVD 1261R, Lingsgar 13, CRS 13, SVD 1523R, SVD 1526R, SVD 1527R, SVD 1529R, SVD 1536R, SVD 1558R, SVD 1432R, SVD 1353R, SVD 1422R, SVD 1263R, SVD 0771R, SVD 0805R, EP 110, EP 87, EP 83, SVD 1265R, EC 32, Yaragatti local, CSV 216R

4. Conclusion

Rust has become major constraint for sorghum production in recent years therefore; an attempt was made to identify of resistant sources in sorghum genotypes. Out of 305 sorghum genotypes screened, none of the genotypes showed highly resistant reaction or immune reaction, only 1 showed resistant reaction (E-4), 16 genotypes showed moderately resistant reaction, 30 showed moderately susceptible, 170 recorded susceptible reactions and remaining 88 were found highly susceptible reaction under natural epiphytotic condition. Further this data can be used to develop resistant varieties and hybrids in sorghum to rust disease.

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