

## 7. Sorghum Pathology

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### Executive summary

**I. Disease scenario:** Grain mold of sorghum has been found to be most damaging disease of sorghum in rainy crop. Periodic visits to farmers fields revealed severe to moderate incidence of grain mold in states of AP, MS, TN and Karnataka. The disease was comparatively less in Marathwada region as compared to in Vidharbha of Maharashtra and that could be attributed to scanty rains in grain filling stage and also observed that varieties were less susceptible than Hybrids. Foliar diseases like zonate leaf spot & anthracnose was moderate in July but in August it took severe forms due rains and. severe incidence of anthracnose and zonate leaf spots was recorded on SPV 1616, CSH-18 in Rajasthan.

In Pantnagar region Anthracnose and zonate leaf spot were found often severe with total precipitation of 1144.0 mm spread over 33 rainy days. The severity of these diseases was observed high on varieties PC-6, CSV-15, SPV 1616 and local cultivars. The incidence of downy mildew was 7.6% in Karnataka whereas it was 63% Coimbatore district of TN.

### II. Summary of trials and Nurseries: all observations using 1-9 rating scale)-

#### Advanced Varietal/ Hybrid Trial I (Zone I)

- i. Grain mold:* SPV 1774 and SPV 1775 recorded lowest severity (rating 3.9) of g against rating 6 in susceptible check.
- ii. Rust:* SPH 1577 recorded lowest incidence (severity scale 3) of rust under high disease pressure in Dharwad.
- iii. Anthracnose:* SPH1577 (Hybrid) and SPV SPV1696 (Var.) showed high level of resistance (1.8) followed by SPV 1774, SPV 1775, and SPH 1596.
- iv. Zonate Leaf Spot:* All test entries recorded moderate level of resistance.
- v. Target Leaf spot:* Entries viz., SPV 1774, SPV 1775, SPV 1600, SPH 1577, SPV 1596 recorded he lowest disease rating (<2.0).
- vi. Downy mildew:* All the entries were found resistant (4-7% incidence) to SDM.
- vii. Ergot:* Ergot was found severe in local check over test entries at Dharwad and Surat.

#### Advanced Varietal/ Hybrid Trial (Zone II).

- i. Grain molds:* None of he test varieties/hybrids were resistant to grain molds.
- ii. Zonate leaf spot:* Only SPV 1746 (2.83) was highly resistant.
- iii. Target leaf spot:* SPV 1746 & SPV 1786 indicated highly resistance.
- iv. Leaf blight:* SPV 1786 (2.70) was highly resistant.
- v. Downy mildew:* All test entries were resistant (<5% incidence).
- vi. Ergot:* All the test entries at Dharwad were resistant to ergot.

### **In Advanced Varietal/ Hybrid Trial (Zone III)**

- i. Grain molds:* None of the test entries were resistant to grain molds.
- ii. Anthracnose.* Five entries - SPH 159, SPV 1786, SPV 1775, SPV 1774 and SPV 1600 were resistant over check Kekri local recorded 7.62 on 1-9 scale.
- iii. Zonate Leaf Spot:* Moderate levels of resistance was observed in all the entries.
- iv. Target leaf spot (Udaipur):* Five entries SPV 1774, SPV 1737, SPV 1730, SPH 1596, SPV 1746 were highly resistant.

### **Initial Varietal Trial-**

- i. Grain molds:* None of the entry maws resistant to grain molds.
- ii. Rust* SPV 1814 and SPV 1815 were highly resistant.
- iii. Anthracnose(Pantnaga):* SPV 1818 and SPV 1819 were moderately resistant.
- iv. Zonate leaf spot:* SPV 1808, SPV 1813, SPV 1815, SPV 1827, SPV 1818 and SPV 1819 were resistant.
- v. Target leaf spot:* All the test entries were resistant at Udaipur.
- vi. Downy mildew:* All the test entries were resistant to downy mildew at Dharwad center

### **Initial Hybrid Trial:**

- i. Grain molds:* SPH 1605, SPH 1603, SPH 1609 and SPH 1614 were moderate in resistance.
- ii. Zonate leaf spot:* Highly resistant entries- SPH 1603 and SPH 1604.
- iii. Target leaf spot (Udaipur):* SPH 1604, SPH 1606 and SPH 1610 recorded highest resistance.
- iv. Downy mildew:* All the entries except SPH 1613 revealed resistant reaction.

### **Dual Purpose Advanced Varietal/ Hybrid Trial**

- i. Grain mold* All the test entries were highly susceptible..
- ii. Zonate leaf spot:* only moderate resistance reaction recorded.
- iii. Downy mildew (Dharwad):* All entries found resistant.
- iv. Ergot:* Inadequate inoculum to arrive at conclusion.

### **Dual Purpose Initial Varietal Trial:**

- i. Grain molds:* None found resistant.
- ii. Rust* High resistance in SPV 1822 & SPV 1823.
- iii. Anthracnose* SPV 1824, SPV 1823 and SPV 1822 highly resistant.
- iv. Zonate leaf spot:* SPV 1822 was highly resistant.
- v. Target leaf spot:* SPV 1822, SPV 1823, SPV 1824 and SPV 1826 highly resistant.
- vi. Leaf blight (Udaipur)* SPV 1823, SPV 1826 resistant reaction.
- vii. Downy mildew:* All test entries recorded resistance.

### **Sorghum Grain Mold Resistant Stability Nursery Coimbatore, Dharwad, Palem, Parbhani and Patancheru:**

Grain mold Field Grade: Only 27 entries showed score of <3.9 on all India basis. Entries ICSB 355, IS 8385-1, IS 621-10, IS 9470-2, IS 18153-9 mold score of 3.0 to 3.1. Some of these entries also have resistance against rust and zonate leaf spot.

**Sorghum Leaf Blight Virulence Nursery:** Variability in populations of *Exserohilum turcicum*, was observed using 20 sorghum lines.

### **Downy Mildew Studies**

**Sorghum Downy mildew Nursery I:** Two entries with s.no 29 (SPV 462 X IS 7528) and 55 (IMS 9BX IS 7528) were found to be highly susceptible rest all recorded moderate resistance.

## **Sorghum pathology report**

The observations on grain mold in most of the centers were recorded on 1-5 scale as decided in the previous workshop. However, lot of in depth discussions were held to revise and improve the scales from 1-5 to 1-9 for recording all parameters of pathology, entomology and physiology disciplines. Accordingly 1-9 scale, which has high precision, was implemented. Some centers have recorded the observations on 1-9 scale, which were put as it is, where as in some centers, 1-5 scale only was applied. These data on 1-5 scale is converted to 1-9 scale using a conversion factor. The percentage disease incidence is transformed into arc sine values. 100 Seed weight is kept as such. For developing grain molds at Parbhani and Palem centers, sprinkler sets were installed. In other centers screening was done under natural conditions only. Early sowings were taken up so that at crop maturity stage severe rain fall was received, which resulted in the development of high incidence of grain molds.

For inducing foliar diseases in hot spots, artificial epidemic conditions were created by planting infector and indicator rows with a highly susceptible entry Kekri local and Sapanda local in Udaipur and Pantnagar centers. Artificial inoculations with anthracnose, zonate leaf spot and target leaf spot were done by growing the culture on autoclaved sorghum grain medium. Incidence of rust was recorded under natural incidence levels only. High levels of incidence of foliar diseases were induced in the susceptible checks from 35-60 days of sowing.

**Advanced Varietal/ Hybrid Trial - Zone 1, Trial I:** In this trial, two hybrids and 9 varieties were tested along with 11 checks (consisting of variety/hybrid/resistant checks) in all the centers. However these entries are designed for testing at Palem and Coimbatore centers which are coming under Zone I. The mean grain mold incidence was high at Dharwad (5.7 LSI Location severity index) followed by Coimbatore (5.6LSI).

In Zone I, the performance of entries SPV 1774 and SPV 1775 appears numerically superior with lowest incidence of grain molds of 3.9 on 1-9 scale, where in the resistant checks recorded 2.6, while susceptible checks recorded 6.0. Threshed grade mold rating of entry 1774 and SPV 1775 was less (3.0 and 3.8) compared to other tested. On all India bases the performance of two entries viz., SPV 1742 and SPV 1746 is good with a mold score of 3.8 and 3.9 showing moderate resistance level. The 100 seed weight of checks was found superior compared to the test entries and hybrids. *Days to 50% flowering.* All the test varieties and hybrids took one week more than the standard check SPV 1666, which flowered in 70 days, while all rest flowered in 75-76 days.

*Grain affected:* The percent grains affected varied from 25 to 54%. With a mean of 38.1%.

*Germination%* in the affected grains varied from 40% to 67%. The highest being in the resistant checks with 66-67%. The mold resistant entries 1774, 1742 and 1746 recorded 35% grain affected by fungi with germination percent of 52%.

*Fusarium moniliforme* incidence varied from 18- 31% with an overall mean of 23%, while *Curvularia* incidence was only 19% at Palem location. The Fusarial populations are very high compared to other fungi

#### *Foliar Diseases:*

*Rust:* Among foliar diseases, the incidence of rust was severe during this year at Dharwad centre with a mean incidence of 4.7, followed by Coimbatore (93.31), Udaipur (2.33) and Mauranipur. The climatic conditions at Dharwad and Coimbatore favored very much for the high development of rust compared to dry regions like Udaipur and Mauranipur centers. Only one hybrid SPH 1577 recorded lowest incidence of rust under high pressure areas like Dharwad with an incidence of 3.0 on 1-9 scale. In view of high variations in the levels of infection, varietal difference could not be evaluated properly.

*Anthracnose* The incidence of anthracnose was severe at Pantnagar with a mean incidence of 4.9, followed by Mauranipur (2.72), Udaipur (2.56) and Surat (2.47). One hybrid SPH1577 and one variety SPV SPV1696 recorded the lowest incidence of anthracnose and possess high level of resistance (1.8). These two entries are followed by SPV 1774, SPV 1775, SPH 1596, SPV 1742 and SPV 1746 with a disease incidence of 2.7 as against susceptible check recording 7.80

*Grey Leaf spot:* The incidence of grey leaf spot was observed at Surat and Mauranipur centers, but the level of disease pressure is not adequate to judge the performance of entries for this disease.

*Zonate Leaf Spot:* The incidence of Zonate leaf spot was severe at Pantnagar with a mean incidence of 4.68, followed by Udaipur centre with (4.42) and Dharwad (3.11). Surat and Mauranipur centers recorded the lowest disease incidence. All released checks recorded <3 grade on 1-9 scale. All test entries recorded moderate level of resistance except one test entry SPV 1630 which recorded highly susceptible reaction of 4.53. The susceptible check recorded 5.94 on 1-9 scale.

*Rough Leaf Spot and Sooty stripe:* The disease pressure is inadequate and hence valid conclusions could not be drawn.

*Leaf blight:* The incidence of leaf blight was observed in Mauranipur (2.68) and Udaipur (2.71). The lowest incidence of 2. Was observed in Surat.

*Target Leaf spot.* The incidence of target leaf spot was recorded at Udaipur (3.04) and Dharwad centers. (1.4). The entries SPV 1774, SPV 1775, SPV 1600, SPH 1577, SPV 1596 recorded the lowest disease incidence of <2.0 on 1-9 scale as against a susceptible entry recording 6.12 on 1-9 scale.

*Downy mildew:* The incidence was found at Dharwad only where in all the entries have recorded the lowest incidence of 4-7% only with an average incidence of 6%. Compared to local check, all the entries showed resistant reaction.

*Ergot:* Ergot incidence was observed at Dharwad and Surat centers, where in except local check all entries showed resistant reaction only.

**Advanced Varietal/ Hybrid Trial - Zone II:** This trial was conducted in all the locations. In this trial one hybrid viz., SPH 1567 and 5 varieties were tested along with 13 checks for their reaction to grain mold and foliar diseases

*Grain molds:* The incidence of grain molds was severe at Palem (6.7) followed by Dharwad, Coimbatore, Akola and Parbhani. The incidence of mold was quite low at Parbhani with a mean incidence of 3 on 1-9 scale. None of the test

varieties/hybrids are resistant to grain molds at all the locations tested as indicated by their field as well as threshed grade mold rating.

*Days to 50% flowering.* The flowering dates of test entries varied from centre to centre. The average 50% flowering was 70 days in Parbhani, Akola and Dharwad, while it was 87 days at Surat. Flowering dates varied from 69-70 days, which is on par with that of CSV 15 and CSV-17.

*Grains affected %.* Highest grains affected was found at Palem as the severity of mold was also very high (48.4%), followed by Parbhani and Akola. The grains affected in the test entries varied from 31 to 59% at Palem

*Fungal association.* *Fusarium moniliforme* was very high at Palem (23.8%) and Parbhani (22.2%). Incidence of *Fusarium* was more at Palem (23.8%) followed by Parbhani (22.2) and Akola (19.6). *Curvularia lunata* was severe at Akola center with a mean incidence of 25.8% followed by Parbhani (22.1) and Palem centre (20.4). Other fungi associated varied from 19 to 25%.

Germination percent in the test entries varied from 52.0 to 63.5%, while resistant checks recorded 62.8%. Parbhani centre had high germination percentage of 67.5% followed by Akola and Palem (48.8%)

*100 seed weight:* The 100 seed weight of SPV 1672 was 2.55 g indicating bolder grain of the entry, all other entries had a test weight of 1.7 to 2.3 g/100 seed weight.

*Rust:* The incidence of rust was severe at Dharwad centre (4.84) followed by Coimbatore (3.31), Udaipur (2.07) and Mauranipur (1.80). None of the test entries were found to be highly resistant as the significant differences were not observed.

*Anthracnose* Severe incidence of anthracnose was found at Pantnagar with a mean incidence of (4.60). However none of the entries were found to be resistant to anthracnose.

*Grey leaf spot:* The incidence of GLS was recorded at Surat and Mauranipur centers but the disease pressure was too less to draw any valid conclusions.

*Zonate leaf spot:* Severe incidence of ZLS was recorded at Pantnagar (4.60) followed by Udaipur (4.28), Mauranipur (3.04). Surat recorded the lowest incidence of 1.80 only. One entry viz., SPV 1746 (2.83) was highly resistant with <3 grade on 1 to 9

*Rough leaf spot:* The disease pressure was inadequate and the results are not significant

*Target leaf spot:* The incidence was observed at Udaipur center with a location severity index of (3.17), low incidence was found at Dharwad (1.18). At Udaipur center two entries viz., SPV 1746 (2.40), SPV 1786 (2.70) were found to be highly resistant.

*Leaf blight:* The disease incidence was severe at Mauranipur (3.35) followed by Udaipur (2.66). Surat recorded the lowest incidence of disease pressure. One entry viz., SPV 1786 (2.70) was highly resistant with lowest incidence of disease.

*Sooty stripe.* The disease pressure is too less and valid conclusions could not be drawn

*Downy mildew:* Recorded only at Dharwad, all test entries were resistant with <5% incidence of downy mildew as against check which recorded 12% incidence

*Ergot:* The incidence of ergot was recorded only at Dharwad, all test entries were resistant to ergot, only susceptible check recorded highest incidence of 12%.

**Advanced Varietal/ Hybrid Trial - Zone III:** In this trial 8 varieties and 3 hybrids were tested in all the locations along with 11 checks including hybrids/ varieties/ resistant checks.

*Grain molds:* The incidence of grain mold was severe at Palem (6.6) followed by Coimbatore (5.6) and Surat (2.4). None of the test entries were resistant to grain molds as per the field as well as threshed grade mold ratings recorded in all the centers for all the entries.

*Days to 50% flowering.* All the test entries flowered from 75 to 80 days which is on par with that of checks.

Grains affected% varied from 48 to 54%, while resistant checks recorded 30% grains affected with molds.

Fungal association

*Germination %:* in checks was very high ranging from 66 to 72%, while the test entries recorded a germination of 40 to 50% only

*100 seed weight:* SPV 1616 a standard check has bolder grain with highest 100 grain weight of 2.31 g, while all the test entries had 1.98 to 2.3 grams/100 seed.

*Rust:* The incidence of rust was severe at Coimbatore, while it was almost nil at Mauranipur centre and Udaipur. At Coimbatore all the entries recorded susceptible reaction. However none of the entries were having high levels of resistance. And all were on par with each other.

*Anthracnose* The incidence of anthracnose was severe at Pantnagar (4.45) followed by Mauranipur (3.23). The diseases incidence ranged from 2.4 to 7.62. The entries SPH 1596 (2.4), SPV 1786 (2.70), SPV 1775(2.48), SPV 1774 (2.85), SPV 1600 (2.55) were numerically superior over other entries and checks. The susceptible check Kekri local recorded 7.62 on 1-9 scale.

*Grey leaf spot* incidence was severe at Mauranipur (3.07) while negligible at Surat. However varietal differences are not significant and hence valid conclusions could not be drawn.

*Zonate Leaf Spot*: The incidence of ZLS was severe at Pantnagar and Udaipur (4.74), the incidence was low at Mauranipur and there was no incidence at Surat. . Moderate levels of resistance was observed in all the entries tested with a range of 3.1 to 3.5

*Target leaf spot*: The incidence of target leaf spot was found at Udaipur, where in entries SPV 1774 (1.80), SPV 1737(2.40), SPV 1730 (2.40), SPH 1596 (2.40), SPV 1746 (2.40) were found to be highly resistant to target leaf spot incidence.

*Sooty stripe*: The disease pressure is too low and the results are non significant

**Initial Varietal Trial (IVT)**: In this trial 16 varieties were tested along with 8 checks for their reaction to grain molds and other foliar diseases at all the centers.

*Grain molds*: The incidence of grain mold was severe at Palem (7.5) followed by Coimbatore (5.7) and Akola (4.4). The incidence was too less at Surat. However all test entries were on par with each other and none of them were found resistant both in terms of field as well as threshed grade mold. The resistant checks recorded 2.7 to 2.8, while the test entries and susceptible checks recorded 5.0 and above.

*Days to 50% flowering*: All the test entries were of medium in duration which flowered in 71 to 72 days at Parbhani and Dharwad, while it is 84 days at Surat.

*Grains affected%*: Palem recorded the highest percent grain affected (50.9) followed by Parbhani (30.5) and Akola (22.4). In the test entries percent grain affected varied from 31 to 38%.

*Fungal association*: The association of *Fusarium moniliforme* was highest at Palem (26.5%), while Maharashtra centers viz., Akola and Parbhani recorded 19% *Fusarium*. The incidence of *Curvularia* was severe at Akola (26.9%) followed by Parbhani (23.4) and Palem (22.2). Other fungi associated varied from 18 to 23%.

Germination % in test entries varied from 57.3 to 67%. The highest germination was found at Dharwad (65.9%) followed by Akola (64%). The test entries recorded a germination percent of 55 to 60.5%

*100 seed weight*: SPV 1813 recorded highest 100 seed weight of 4.09 g.

*Rust*: the incidence of rust was severe at Coimbatore and Dharwad centers. Two entries viz., SPV 1814 and SPV 1815 were found highly resistant with score of 2.0, while two more entries viz., SPV 1811 and SPV 1812 recorded moderate resistant reaction with 2.67.

*Anthraxnose* was severe at Pantnagar (4.98) followed by Mauranipur (2.78), Surat (2.53) and Udaipur (2.35) At Pantnagar under high disease pressure areas, two entries viz., SPV 1818 (3.6) and SPV 1819(4.2) were resistant.

Grey leaf spot: the incidence is too low and hence valid conclusions could not be drawn.

*Zonate leaf spot* was severe at Pantnagar and Udaipur centers with 4.02. Six entries viz., SPV 1808, SPV 1813, SPV 1815, SPV 1827, SPV 1818 and SPV 1819 were resistant to ZLS with an incidence of 2.7 to 2.9.

*Rough leaf spot*: Disease pressure is inadequate to draw any conclusions.

*Target leaf spot* was severe at Udaipur center all the test entries were resistant compared to local susceptible check

*Leaf blight and Sooty stripe*: Disease pressure is too less, lot of variations is found and the results are non significant and hence valid conclusions could not be drawn.

*Downy mildew*: All the test entries were resistant to downy mildew at Dharwad center

*Ergot*: All the test entries recorded low incidence of ergot at Dharwad centre

*Grain hardness*: Three entries recorded high grain hardness viz., SPV 1813 (9.53), SPV 1814 (9.15) and SPV 1818 (8.92).

**5. Initial Hybrid Trail (IHT)**: In this trial 16 hybrids were evaluated along with 8 checks for their reaction to grain molds and foliar diseases in all the kharif centers.

*Grain molds*: The incidence of grain mold was severe at Palem (7.0) followed by Dharwad (6.3) and Coimbatore (5.6). In this rigorous screening, four entries viz., SPH 1605 (4.9), SPH 1603 (4.7), SPH 1609 (4.7), SPH 1614 (4.4) were found to be resistant to grain molds, which are on par with that of CSH-18. The threshed grade mold rating of these entries was <5.0. The resistant check B 58586 recorded a mold score of 3.5.

*Days to 50% flowering*: The DTF of test entries varied from 71 to 76, but it is longer at Surat center with 84 days. All test entries had 50% flowering ranging from 70 to 77 days which is on par with that of released hybrids.

*Grains affected%*: High percentage of grain affected was found at Palem (50.6%) followed by Parbhani 32.3%. The resistant entries had recorded 30-35%.

*Fungal association*: *Fusarium* infection was (24.6%) at Palem, followed by Parbhani (24.2) and Akola (19.6) while the incidence of *Curvularia lunata* was very severe at Parbhani (28.6%) followed by Akola (27.4). Palem had only 21.6% infection with *C.lunata*. Other fungi associated with molds varied from 19 to 25%

*Germination %*: Germination of test entries was high at Parbhani (65.1%), while it is lowest at Palem, because of higher incidence of molds. Resistant entries recorded 55-60% germination compared to susceptible ones.

*100 seed weight*: SPH 1608 recorded highest 100 seed weight of 2.59 g, which was followed by SPH 1603 (2.54g). All other entries recorded lower 100 seed weight

*Rust*: The incidence of rust was severe at Coimbatore (5.09) and Dharwad (4.88), while it was almost nil at Mauranipur and Udaipur centers However results are not significant and hence valid conclusions could not be drawn.

*Anthracnose* NS: Disease pressure is severe at Pantnagar (4.4%), while at Surat, Udaipur the incidence is too less and the results are not significant and hence valid conclusions could not be drawn.

*Grey leaf spot*: NS the disease pressure is too low

*Zonate leaf spot*: Severe incidence of Zonate Leaf spot was recorded at Pantnagar (4.53), followed by Udaipur (4.44) and Dharwad (3.05). High level of resistance was found in two entries viz., SPH 1603 (2.74) and SPH 1604 (2.94). Others had moderate levels of resistance, compared to susceptible check Kekri local which recorded 5.76 on 1-9 scale.

*Rough leaf spot*: Disease pressure is too less and non significant results obtained.

*Target leaf spot*: Severe incidence of target leaf spot was recorded at Udaipur, where in three entries viz., SPH 1604, SPH 1606 and SPH 1610 recorded highest resistance to Target leaf spot

Leaf blight was severe at Mauranipur (3.52) followed by Udaipur (2.47)

*Sooty stripe*: Disease pressure is too less and hence valid conclusions could not be drawn

Downy mildew was recorded at Dharwad, where in all the entries recorded resistant reaction except SPH 1613, which recorded 12%, while rest all recorded 4-5 % incidence only

*Ergot*: Incidence was observed at Dharwad, where in all the entries recorded only 5% incidence and hence valid conclusions could not be drawn

*Grain hardness*: SPH 1608 had highest grain hardness of 8.98 followed by SPH 1617 with 8.3 g/Kg<sup>2</sup>

**Dual Purpose Advanced Varietal/ Hybrid Trial (DPAVHT)**: In this trial one hybrid viz., SPH 1467 and 7 varieties were evaluated along with 8 checks for their reaction to grain molds and foliar diseases at all the Kharif centers. The incidence of grain mold was severe at Palem (6.8), followed by Coimbatore (5.6), Akola (4.6), Dharwad (3.7). All the test entries were highly susceptible to grain molds and none were found to have any resistance to grain molds as indicated by overall mean field grade (4.7) as well as threshed grade mold (5.3) incidence. Grain hardness was recorded at Akola centre where highest grain hardness was found in is 14332 a resistant check with 9.78. SPV 1778, SPV 1754, SPV 1750 and SPV 1779 recorded highest grain hardness of >9 Kg/cm<sup>2</sup>. However the data on Grain molds was non significant

*Days to 50% flowering*: The test hybrid flowered in 72 days while varieties flowered in 71 to 78 days which is on par with released checks

*Grains affected%* was very high at Palem with a mean incidence of 49%, followed by Akola (22%). Fungal association due to molds was mostly with fusarium moniliforme up to 22% in Palem, followed by Akola 20%, while Curvularia was very severe at Akola with a mean incidence of 28%, while other fungi varied from 18-22%.

*Germination%* of molded seed was 61% at Akola, while at Palem it is 44%. In the test entries the germination ranged from 47- 63%.

*100 seed weight* of test entries varied from 2.0 to 2.36 and checks is not significantly differing.

*Rust*: The incidence of rust NS. The incidence of rust was severe at Coimbatore with LSI of 4.16 followed by Dharwad (3.49) and Udaipur (2.58). The susceptible check recorded 6.27%. But varietal differences could not be found as there was no significant difference between test entries and checks.

*Anthracnose* NS. Severe at Pantnagar (4.65) followed by Surat (3.28). None of the test entries were found to be superior over the checks.

*Grey leaf spot*: was observed at Surat and Mauranipur, but adequate disease pressure is not available to judge the efficacy of test entries.

*Zonate leaf spot*: The incidence of zonate leaf spot was severe at Pantnagar (4.25), followed by Udaipur (4.38) and Dharwad with 3.37 only. All entries recorded moderate resistance reaction to zonate leaf spot. As against susceptible check recording 5.76.

*Rough leaf spot*: NS varieties are not significantly differing

*Target leaf spot* was recorded only at Udaipur centre with a mean of 4.07.

*Leaf blight*: Incidence was moderate at Mauranipur, followed by Udaipur. However varietal differences could not be evaluated in view of low disease pressure. And the results were non significant.

*Sooty stripe*: Disease pressure was too less at Dharwad and Surat and Mauranipur and hence valid conclusions could not be drawn.

*Downy mildew*: All the test entries were resistant at Dharwad with an incidence of 4 to 9%, while the susceptible check DMS 652 recorded 20% incidence.

*Ergot* incidence was too less and inadequate to identify resistant ones.

**Dual Purpose Initial Varietal Trial**: In this trial 6 entries were evaluated along with 7 checks comprising local, national and resistant checks in all the Kharif locations for their reaction to grain molds and foliar diseases.

*Grain molds*: The incidence of grain mold was severe at Palem followed by Coimbatore, Dharwad and Akola. None of the entries tested were resistant to grain mold in all the centers as the mold range is varying from 4.5 to 5.5, mold pressure is too high and the results are non significant. The overall FGMR was 4.6, while TGMR was 5.2. Severe incidence of mold was observed in all centers with percent grain affected varying from 29 to 40% with more infection of

Fusarium at Palem (23%, while severe incidence of Curvularia was recorded at Akola center with 26%. Grain hardness in SPV 1821 was highest with 9.35.

*Days to 50% flowering*: The test entries flowered from 70 to 80 days indicating medium duration  
100 seed weight of test entry SPV 1821 was highest with 2.39g.

*Rust*: The incidence of rust was severe at Dharwad centre, where in two entries viz., SPV 1822 and SPV 1823 were found to possess high levels of resistance. All others showed susceptible reaction.

*Anthracnose* Severe at Pantnagar(4.8), followed by Mauranipur (3.24). Three entries viz., SPV 1824 (2.7), SPV 1823 (2.8) and SPV 1822 (2.7) recorded high levels of resistance to anthracnose.

*Grey leaf spot*: Rough leaf spot: The incidence is too less and results are non significant and hence valid conclusions could not be drawn.

*Zonate leaf spot*: Only one entry viz., SPV 1822 was highly resistant to zonate leaf spot with an incidence of 2.74 as against check kekri local with 5.94.

*Target leaf spot*: Target leaf spot was severe at Udaipur, where in four entries viz., SPV 1822 (2.4), SPV 1823 (2.7), SPV 1824 (1.8) and SPV 1826 (2.4) were found resistant.

*Leaf blight* incidence was severe in Zone III locations, where in two entries viz., SPV 1823 (2.70), SPV 1826 (2.40) recorded resistant reaction at Udaipur, where high incidence was observed.

*Sooty stripe* and ergot incidence is too less and results are not significant

*Downy mildew* found at Dharwad, where in all the entries recorded resistant reaction.

### **Pest and Disease Resistant Nursery**

**Pest and Disease Resistant Nursery (PDRN) -Kharif 2007**: Efforts were initiated to conduct interdisciplinary trials. The first pest and disease nursery (PDRN) trial was taken up with a view to identify insect pest and disease resistant material. Twelve test entries (consisting of 6 grain mold resistant entries and 4 shoot fly resistant entries along with, susceptible and local check each one were tested for resistance against shoot fly, stem borer, grain molds and foliar diseases at three locations viz., at Parbhani, Dharwad (Zone II) and Udaipur (Zone III)

*Grain molds*: Severe incidence of grain mold was recorded at Dharwad, However as the results are non significant for grain molds, valid conclusions could not be drawn. All shoot fly resistant material was highly susceptible to grain molds and rust.

*Downy mildew* resistance was observed in the shoot fly resistant material

*Shoot fly* resistant entry viz., NRCS FRO 6-1 is resistant to all foliar diseases viz., rust, zonate leaf spot and target leaf spot as they have recorded high levels of resistance

*Shoot fly*: Dead hearts caused due to shoot fly was recorded at 28 DAE. The data from Parbhani (Zone-II) showed the shoot fly incidence ranged from 25.9 – 95.4%. The entries SUENT -8 and SUENT 9 recorded lower dead hearts (35.9 and 40.4%) and were on par with resistant checks (IS 18551, IS 2312). At Dharwad (zone-II), the shoot fly incidence ranged from 17.6 – 88.6%. The entries NRCSFR06-1, NRCSFR 06-2, Local, BY (S-GM) and SUENT 9 recorded lower dead hearts (19.7- 27.9%). At Udaipur (Zone III), the shoot fly dead hearts ranged from 9.1 – 91.7 %. The entry SUENT-8 recorded significantly low dead hearts (15.5%) and was on par with resistant check IS 2312. The shoot fly dead hearts ranged from 17.5 – 91.1 %) across the locations & zone the entries SUENT 9, SUENT 8, Local check, NRCSFR06-2 and NRCSFR06-1 were significantly superior and were on par with Resistant check IS 2312, the dead hearts in these entries ranged from 28.8-34.7%). The data on shoot fly eggs/10 plants was rejected owing to high CV at all the locations (Table 9.1)

*Stem borer* at all the centers, low levels of borer infestation were observed in the form of dead hearts (< 6%). At Parbhani (Zone II) the entries SUENT 9 and NRCSFR06-1 recorded lowest stem borer dead hearts and were on par with resistant check.

**Parental Line Trial**: In parental Line testing a total of 154 entries including 4 checks were evaluated at all hot spot centers for their reaction to major diseases like grain molds, downy mildew and foliar diseases.

*Grain molds*: For grain mold analysis, data received from four centers viz., Dharwad, Palem, Coimbatore and Akola centers only was considered. Some lines in some centers did not germinate properly and the data was not provided. Uniform data available from all these four centers was considered for 111 entries+ 4 checks at all the four locations. None of the parents were found resistant to grain molds as the mold ranged from 4.5 to 7.0 in the test entries at all the locations.

*Rust*: Severe incidence of rust was recorded at Dharwad and Coimbatore centers and hence data from these centers was considered. Out of 150 entries sent, data from consistent and uniform 80 entries was analyzed, in which 15 entries recorded high resistant reaction to rust in the hot spots.

### **Foliar Diseases**

*Anthracnose* The incidence of anthracnose was recorded at Udaipur, Mauranipur and Pantnagar, the hot spot locations for anthracnose. Severe incidence was recorded at Pant Nagar and Mauranipur, while moderate incidence was

recorded at Udaipur and uniform data from 88 entries was analyzed. Of the 150 entries evaluated, data was available for 88 entries, in which 39 entries recorded < 2.5 grade on 1-9 scale and were resistant.

*Zonate Leaf spot:* High disease pressure was recorded at Dharwad, Mauranipur, and Udaipur and Pantnagar centers. Out of 150 entries evaluated, 33 were resistant to zonate leaf spot with an incidence of <3.0 on 1-9 scale.

*Downy mildew:* Severe incidence of downy mildew was recorded at Dharwad and Coimbatore centers, where in out of 150 entries, data was available for 80 entries from all the locations, which was analyzed and 66 entries were resistant with an incidence of 4 to 10%. Others recorded from 11-25% of disease.

## **Sorghum grain mold resistant stability nursery**

The Sorghum Grain mold Resistance Stability Nursery (SGMRSN -2007) was conducted at five locations viz., Coimbatore, Dharwad, Palem, Parbhani and Patancheru. The nursery consisted of 50 entries including 6 white grained mold resistant entries from NRCS and 40 entries (Inbred lines including A-lines and R-lines) with red, brown colored seeds from ICRISAT center along with two resistant (IS 25017 and IS 14384), one moderately resistant (PVK 801) and one susceptible (SPV 104) checks. Checks are planted after every 10 test entries. The details of the entries are appended at the end. The nursery was grown in a RCB design with 3 replications. Each entry was grown in 2 rows of 4 m long. High relative humidity (>90% RH) was created by sprinkler irrigation on rain-free days at Patancheru and some other locations. No artificial inoculation with any mold fungi was done. Sprinkler irrigation was provided from flowering to physiological maturity to promote mold development. Five plants with uniform flowering were tagged in each row (10 plants plot<sup>-1</sup>), and grain mold severity was measured as the panicle grain mold rating (PGMR) at physiological maturity on a 1-5 scale (1= no mold, 2= 1-10%, 3= 11-25%, 4= 26-50% and 5= >50% grains molded in a panicle) on the tagged panicles. These observations on 1-5 scale were converted to 1-9 scale by multiplying with a common factor. Tagged panicles were harvested at PM, sun-dried and threshed. Grain hardness was measured for 25 threshed grains from each plot by subjecting to a single grain hardness tester (Kiya Seisakusho Ltd., Tokyo, Japan) after the grain samples were dried to 7% seed moisture level by keeping the samples at 40°C for 2 days. Grain hardness of samples only from Patancheru was recorded. Data on agronomic traits, such as plant height, days to 50% flowering, glumes cover, and grain hardness were also recorded. In addition, at Patancheru data were recorded on panicle type (compactness), glumes color, glumes coverage of grain, grain color and grain hardness as these traits have been shown to be associated with grain mold resistance.

**Results:** Of the 46 test lines, the glume coverage of the test entries varied from 32.6% to 54.2%. The resistant checks IS 25017 and IS 14384 had semi-loose and loose panicles, red and black glumes, 33 and 75% glumes coverage and white and red grains, respectively.

*Days to 50% flowering:* The mean day to 50% flowering was 70 days in all the test centers. The test entries flowered in 64 - 80 days. The lowest number of days taken was found in two entries viz., IC 8385-1 and IS 20835-8 with 64 days followed by IS- 10942-5 and IS 25103 with 65 days. The mean DTF across locations varied from 70 to 71 days. Six entries took 77 to 0 days for flowering, while 25 entries flowered between 60 to 70 days. The mean plant height was highest at Palem with 188 cm, followed by Dharwad (184) and Coimbatore (149 and Parbhani centers (117cms). However this variation is due to the excellent rainfall received at Palem as well as Dharwad with good distribution.

*Grain mold Field Grade:* The incidence of molds at Palem was severe with a location severity index of 6.13, followed by Coimbatore (3.95), Parbhani (2.93) and Dharwad (2.56). Of the 46 entries tested across all locations high level of resistance was recorded in 27 entries with a mold score of <3.9 on 1-9 scale while 5 entries had moderate levels of resistance from 3.9 to 4.25 and the rest had high susceptibility. Location mean at Parbhani was too less this year with 2.93 only, where in even susceptible check could not cross 5 marks on 1-9 scale. High level of resistance was observed in five entries viz., ICSB 355, IS 8385-1, IS 621-10, IS 9470-2, IS 18153-9 which recorded a mold score of 3.0 to 3.1 only and has high promise. Twenty two entries had a score from 3.1 to 3.9 which is on par with that of resistant checks tested; these entries flowered from 65-68 days which is falling in the medium duration group. These entries have high potential for grain mold resistance and can be utilized for the development of high yielding mold resistant lines. Interestingly twelve of these lines possess high levels of resistance to rust which is a serious foliar diseases at Dharwad. Eighteen entries recorded high levels of zonate leaf spot also

## **Sorghum leaf blight virulence nursery**

**ICAR ICRISAT Project SG1:** Breeding for trait-based sorghum hybrid parents for specific end-uses and their testing for use in the national program

**Objective:** To characterize variability in populations of *Exserohilum turcicum*, the leaf blight pathogen from different Agro ecological zones viz., Dharwad, Udaipur and Hyderabad and Identify sources of stable resistance to LB

The Sorghum Leaf blight Virulence Nursery comprising of 20 lines was conducted at three locations viz., Udaipur, Patancheru (ICRISAT) and Dharwad in Kharif 2007. The nursery comprised of 19 sorghum lines that had shown differential reactions to the populations of the pathogen in preliminary studies, and one susceptible line IS 18442 as check. Each entry was grown in two rows of 4m long in two replications. Standard cultural practices for crop management were followed according to the local recommendations. At Patancheru the entries were planted in September and overhead sprinklers were provided to maintain humidity above 90%, while at Udaipur and Dharwad, planting was done in July and during dry spells humidity was provided by irrigations. The entries were inoculated with actively growing culture of the local isolate of *E. turcicum* grown for 10 days on autoclaved sorghum grains, air-dried and 2-3 grains placed in whorls of 25-days- old plants. Ten plants in each entry in each replication were randomly tagged for recording observations. Observations for leaf blight severity were recorded at soft-dough stage, on the standard 1-5 scale Based on the per cent of the total leaf area infected, where 1= No symptoms seen on leaves; 2 = Traces to 10 per cent leaf area infected; 3 = 11 to 25 per cent leaf area infected, 4 = 26 to 50 per cent leaf area infected, and 5=Above 50 per cent of leaf area infected .The weather data during the crop were also collected. For discerning disease reaction, disease scores of 1 to 2 were considered as resistant (R) reaction, 2.1 to 3.0 as moderately resistant (MR), and 3.1 to 5.0 as susceptible (S) reactions. The disease pressure at Patancheru and Udaipur was good as the susceptible check IS 18442 developed mean disease scores of 5.0 and 4.6, respectively, showing susceptible reaction to leaf blight but at Dharwad, disease did not develop at all and hence the data from Dharwad have not been included in this report.

Some entries showed differential reaction at Udaipur and Patancheru. IS 2834 showed R reaction at Patancheru but S (mean score 3.2) at Udaipur, while IS 3490 was S (mean score 4.1) at Patancheru but R (mean score 2.0) at Udaipur. Similarly, IS 25400 and IS 26866 showed S reaction (mean score 3.1 and 5.0, respectively) at Patancheru, but R (mean score 1.0 and 1.4, respectively) at Udaipur (Table 1). IS 26863 showed MR reaction (score 2.8) at Patancheru, but R reaction at Udaipur. IS 30403, IS 20944 and IS 22545 developed higher scores of LB (5.0, 5.0 and 4.9, respectively) at Patancheru as compared to 3.3, 3.6 (S reaction) and 2.6 (MR reaction), respectively, at Udaipur. IS 9303 showed R reaction at both the locations, while IS 12466, IS 13904, IS 18668 and IS 19163 showed MR reaction to leaf blight at both the locations. Pooled ANOVA (Table 2).for leaf blight severity across the two locations revealed significant ( $P=0.001$ ) effects of locations, genotypes and Location  $\times$  Genotypes interactions.

**Table 1. Leaf blight severity of the 20-entry Sorghum Leaf Blight Virulence Nursery (SLBVN) during 2007 rainy season at two locations.**

Ent No	Entry	Leaf blight severity (1-5 scale) <sup>a</sup>		
		Patancheru	Udaipur	Mean
1	IS 2683	2.4	2.3	2.3
2	IS 2834	1.3	3.2	2.3
3	IS 3490	4.1	2.0	3.0
4	IS 9303	2.0	1.0	1.5
5	IS 10284	4.5	3.3	3.9
6	IS 10775	3.9	3.2	3.5
7	IS 12466	2.6	2.7	2.6
8	IS 13057	2.7	3.1	2.9
9	IS 13904	2.2	2.1	2.1
10	IS 15745	3.6	3.8	3.7
11	IS 18668	2.3	2.0	2.1
12	IS 19163	2.3	1.8	2.0
13	IS 20944	5.0	3.6	4.3
14	IS 22545	4.9	2.6	3.7
15	IS 25069	2.3	3.0	2.6
16	IS 25400	3.2	1.4	2.3
17	IS 26863	2.8	1.0	1.9
18	IS 26866	3.1	1.6	2.3
19	IS 30403	5.0	3.3	4.1
20	IS 18442 (sus check)	5.0	4.8	4.9
	Mean	3.2	2.6	2.9
	SE (m)±	0.24	0.09	0.17
	LSD ( $P<0.05$ )	0.72	0.28	0.50
	CV (%)	10.6	5.1	7.9

<sup>a</sup>Mean of 2 replications, 10 tagged plants/replication based on 1-5 scale, Where 1= no symptoms/chlorotic flecks; 2 = up to 10% leaf area covered with small restricted lesions; 3=11-25% leaf areas covered with lesions; 4=26-50% leaf area covered with large coalescing lesions and 5=>50% leaf area covered with large coalescing lesions.

**Table 2. Pooled ANOVA for leaf blight severity across two locations (Patancheru and Udaipur)**

Source of variation	df	SS	MS
Replication	1	0.28561	0.28561
Location (L)	1	8.45000	8.45000***
Genotypes (G)	19	67.08295	3.53068***
Location × genotype	19	21.80395	1.14758***
Residual	39	2.77130	0.07106
<b>Total</b>	<b>79</b>		

\*\*\*Significant at  $P < 0.001$ .

## Sorghum downy mildew

**Sorghum Downy mildew Nursery I:** In this trial, a total of 57 entries (cross progenies along with parents consisting of downy mildew resistant entries viz., is 14332, IS 3443 and is 7528 and a susceptible check DMS 652) were evaluated at two locations viz., Dharwad and Coimbatore under high disease pressure for their reaction to downy mildew and foliar diseases. Dharwad recorded high incidence of downy mildew with a location mean of 8.8, followed by Coimbatore with 6.5. Of the 57 entries tested, three did not germinate, while 52 entries recorded resistance reaction to downy mildew. Two entries with s.no 29 (SPV 462 X IS 7528) and 55 (IMS 9BX IS 7528) were found to be highly susceptible as these entries recorded a downy mildew incidence of 18%. Rest all entries had an incidence of 4 to 11 % only. A high level of resistance with an incidence of 4.05 was found in 17 entries. The local susceptible check recorded an incidence of 35%. **Grain molds:** Six entries with entry numbers 15, 16, 20, 28, 42 and 48 recorded high degree of resistance to grain molds with a score of 2-2.5 on 1-9 scale

**Rust:** Severe incidence of rust was recorded in this year. Eight entries (entry nos 47, 46, 50, 49, 48, 44, 5 and 4) were found resistant to rust.

**Zonate Leaf Spot:** Seventeen entries recorded high level of resistance to zonate leaf spot. Sooty and Target leaf spot pressure was inadequate to rate these entries.

**Sorghum Downy Mildew Nursery II:** In this trial 21 IS lines which have shown resistant reaction earlier trials were evaluated for their reaction to various other diseases besides downy mildew. All the entries have recorded the lowest incidence of downy mildew ranging from 4. to 7% incidence only. However since the difference between the entries is not significant, all had maintained uniform level of resistance to grain molds. These entries flowered from 67 to 76 days.

**Rust:** High level of rust resistance was observed in 7 entries IS 18757, IS 17141, IS 14387, IS 14375, IS 8607, IS 3547, IS 7528 recorded high levels of resistance with 2.0 to 2.5 grade on 1-9 scale.

**Zonate leaf spot:** Eight entries viz., IS 7528, IS 8185, IS 8607, IS 14332, IS 14375, IS 14387, IS 17141 and IS 18757 were resistant. Sooty and target leaf spot pressure is too less.

**Studies on survival of sorghum anthracnose pathogen (*C.graminicola*):** Sorghum Anthracnose caused by *C.graminicola* is most devastating disease of the crop in Uttarakhand. Studies on the survival of the pathogen on seed were conducted in laboratory using standard blotter method and agar plate method. Both surface sterilized and non sterilized post harvest seeds of var. PC 23 and PC 4 were used and examined under microscope for the presence of the pathogen after 7 days of incubation at  $25 \pm 1^\circ\text{C}$ . Observations were taken periodically at monthly interval. Pathogen has been found to survive on seeds even after 15 months.

**Biological Control:** Seed bioprimering with *T. harzianum* isolates (TH 43 and TH 39) resulted in significant increase in plant height, green fodder yield and reduced disease severity over control.

## Refinement of screening techniques

**Growth stage:** Sorghum growth stages were tested for susceptibility to anthracnose development. The results indicated that, plants were found highly susceptible at eight leaf stage (80.00%) in comparison to two leaves, four leaf stages. It was found that as the growth stage increases the severity of disease increases with the age of the plants.

**Method of inoculation:** Among the screening techniques tested for evaluation of sorghum genotypes to anthracnose disease, conidial spray inoculation on foliage result maximum (70.17%) foliar damage when compare to whorl inoculation with infected grains and detached leaf technique which resulted in (46.85%) and (53.85%) PDI, respectively. The effective conidial spray inoculation will help to screen large number of sorghum genotypes to identify stable resistance sources to anthracnose disease.

**Pest and Disease Resistant Nursery:** In this trial 6 grain mold resistant entries and 4 shoot fly resistant entries were tested for their reaction to grain molds and shoot fly so that we can identify both shoot fly and grain mold resistant entries. Since the results are non significant for grain molds, valid conclusions could not be drawn. All shoot fly resistant material was highly susceptible to grain molds and rust. Downy mildew resistance was observed in the shoot fly

resistant material viz., NRCS FRO 6-1 is good for rust, zonate leaf spot and target leaf spot as they have recorded high levels of resistance.

### **Advanced sweet sorghum varietal / hybrid trial**

In this trial 13-advanced sweet sorghum entries including 4 hybrids and 9 varieties were tested along with 5 checks for their reaction mainly to foliar diseases in the hotspots viz., Dharwad and Udaipur centers.

*Days to 50% flowering* Among the entries tested SPSSH 26 is very early type which flowered in 70 days, while rest of the entries flowered in 74-77 days.

*Rust*: Severe incidence of rust was recorded at followed by Udaipur. Two entries viz., SPSSV 15 and SPSSH 24 recorded the resistant reaction (4.33) on 1-9 scale at both the locations.

*Downy mildew*: All the test entries recorded resistant reaction to downy mildew at Dharwad centre with an incidence of 4-5 % only as against susceptible check recording 20%

*Grain molds*: Two entries viz., SPSSH 30 and SPSSV 11 were resistant to grain molds

*ZonateLS*: Two entries viz., SPSSH24 (2.23) and SPSSH25 (2.57) were resistant to zonate leaf spot

*Target leaf spot*: The incidence of TLS was not observed at Dharwad, while at **Udaipur** the incidence is severe, where in seven **entries** viz., SPSSV 30,26, 15, 20,27, 4 and 30 were resistant to target leaf spot disease

*Anthraco*se A high level of resistance was observed in 4 entries viz., SPSSV 15, 20, 4 and 26.

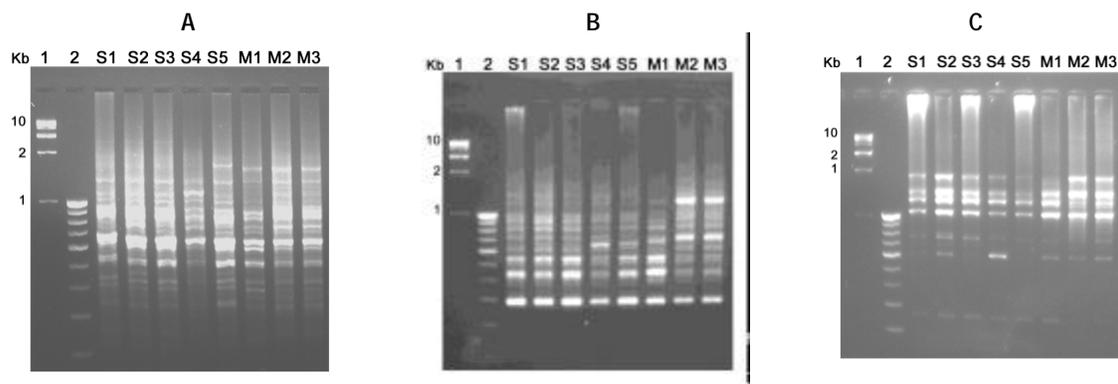
*Leaf blight*: Six entries viz., SPSSV 20, 27, 4, 29, 24 and 25 were resistant

**Variability in isolates of *Peronosclerospora sorghi***: Molecular differentiation of isolates of *Peronosclerospora sorghi* from sorghum and maize using PCR-Based SCAR Marker (TNAU Coimbatore)

The pathogen *Peronosclerospora sorghi* [Weston and Uppal (Shaw)] infects both sorghum as well as maize and causes the devastating downy mildew disease. Pathogenic and molecular variability among isolates of *P. sorghi* from sorghum and maize has been reported. In the present study *P. sorghi* isolates S1, S2, S3, S4, S5, S6 and S7 were collected from different sorghum genotypes and M1, M2, M3, M4, M5, M6 and M7 were collected from different maize genotypes in fields near Coimbatore, India and DNA was extracted from conidia of each isolate according to the method described by McDermott et al. (1994). A total of 7 RAPD 10-mer primers (OPL-08, OPE-01, OPE-18, OPL-05, OPL-07, OPL-12, OPB-15) were tested for their ability to produce informative profiles from genomic DNA of *P. sorghi* isolates from sorghum and maize. A total of 126 clear and reproducible bands ranging between 150 bp and 2500 bp were scored from the RAPD profiles and used in the analysis. The results indicated that all RAPD primers tested produced profiles that clearly showed variability between isolates of *P. sorghi*. Within the isolates of *P. sorghi* from maize, RAPD profiles seemed to be considerably less variable. The RAPD profiles produced with the primers OPL-07, OPL-08 and OPE-01 are shown in Fig. 1. The RAPD primer OPB15 consistently amplified a 1000 bp product in PCR only from DNA of *P. sorghi* isolates from maize and not from isolates of sorghum (Fig. 2a and 2b). Analysis of the genetic coefficient matrix derived from the scores of RAPD profiles showed that minimum and maximum percent similarities among the *P. sorghi* isolates tested were in the range of 37 and 87 % respectively (Fig. 3). Cluster analysis using UPGMA method clearly separated the isolates into three groups (Group I-III) (Fig. 4). The sorghum isolate S4, clustered into a separate group (Group I). All maize isolates were clustered together in Group II and the remaining sorghum isolates belonged to Group III. Isolates from maize formed a single group and these isolates were placed separately from the isolates of *P. sorghi* from sorghum. This study has shown that RAPD analysis of the isolates of *P. sorghi* can be used effectively to distinguish between isolates of *P. sorghi* from sorghum and maize.

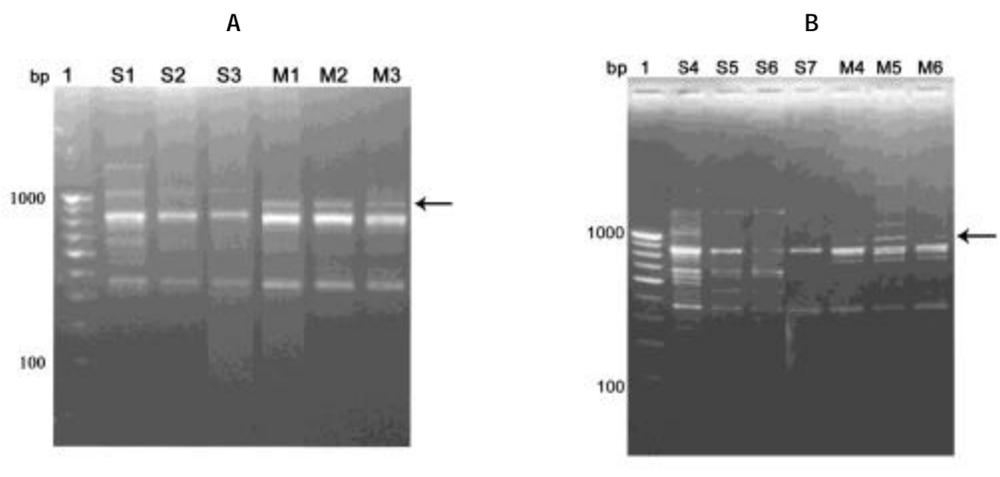
In order to develop a SCAR marker, the unique band (1000 bp) specific to maize isolate (M1) of *P. sorghi* amplified by RAPD primer OPB15 was cloned and sequenced. The nucleotide sequence of the insert fragment was compared with all sequence data available in the GenBank sequence database. However, no identical or nearly identical sequences were found. The sequence of the SCAR marker was used for designing specific PCR primers (SCAR-F and SCAR-R). These primer pairs specifically amplified a 800 bp fragment from the genomic DNA of all *P. sorghi* isolates from maize (Fig. 5). However these primers did not amplify the expected size (800 bp) fragment from genomic DNA of sorghum isolates. The specificity of the primers was confirmed by repeated testing to ensure reproducibility. The SCAR primers developed in this study is highly specific and reproducible that proved to be a powerful tool for differentiation of *P. sorghi* isolates from sorghum and maize.

Fig. 1. Agarose gel electrophoresis of PCR-amplified products from genomic DNA of *P. sorghi* using the RAPD primers OPL-07 (A), OPL-08 (B) and OPE-01 (C).



Lane 1, 1.0 kb DNA ladder; Lane 2, 100 bp DNA ladder; Lanes S1 to S5, *P. sorghi* isolates from sorghum; Lanes M1 to M3, *P. sorghi* isolates from maize.

Fig. 2. Ethidium bromide-stained agarose gel showing amplification products from PCR of genomic DNA of *P. sorghi* using the RAPD primer OPB15



(A) Lane 1, DNA size marker; Lanes S1-S3, *P. sorghi* isolates from sorghum; Lanes M1-M3, *P. sorghi* isolates from maize. (B) Lane 1, DNA size marker; Lanes S4-S7, *P. sorghi* isolates from sorghum; Lanes M4-M6, *P. sorghi* isolates from maize. Arrow indicates the 1.0 kb fragment of *P. sorghi* to design SCAR markers

Fig. 3. Genetic similarity coefficient matrix for *Peronosclerospora sorghi* isolates from sorghum and maize based on RAPD profile

Isolates	S1	S2	S3	S4	S5	M1	M2	M3
S1	1.000							
S2	0.608	1.000						
S3	0.639	0.791	1.000					
S4	0.539	0.418	0.458	1.000				
S5	0.604	0.684	0.790	0.457	1.000			
M1	0.462	0.564	0.554	0.367	0.590	1.000		
M2	0.481	0.612	0.576	0.372	0.563	0.639	1.000	
M3	0.531	0.625	0.604	0.413	0.589	0.712	0.868	1.000

Fig. 4. Un weighted pair group method arithmetic average dendrogram constructed from RAPD data indicating the relationship among the isolates of *Peronosclerospora sorghi* from sorghum (S1- S5) and maize (M1- M3).

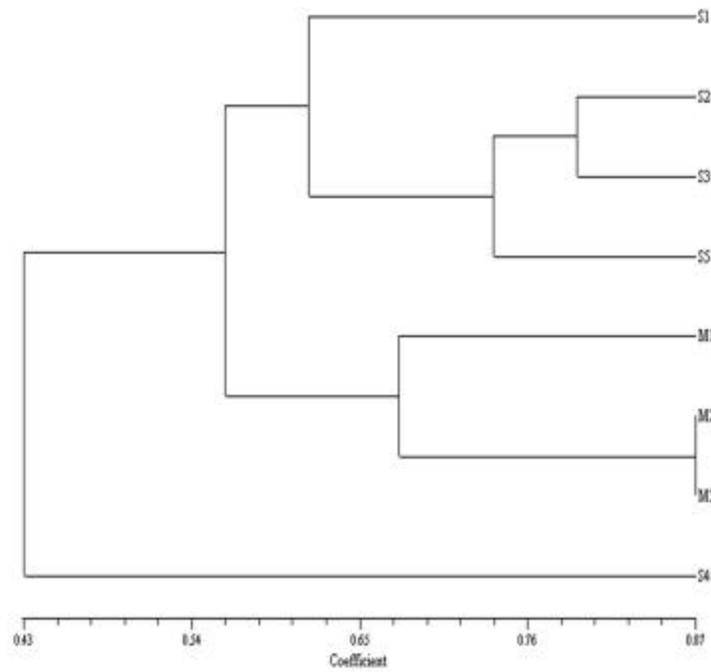
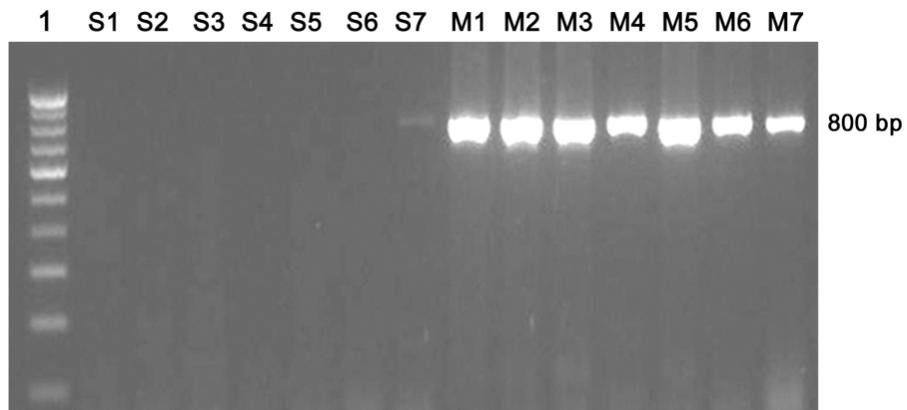


Fig. 5. Agarose gel electrophoresis of PCR products using SCAR primers with genomic DNA from *P. sorghi* isolates



Lane 1, DNA size marker; Lanes S1-S7, *P. sorghi* isolates from sorghum; Lanes M1 –M7 *P. sorghi* isolates from maize

## Annexure I: Performance of centers

Centers	Dis. Sit	AVHT - I	AVHT - II	AVHT - III	IVT	IHT	DPAV HT	DPI VT	PLT	SGM RSN	DM	SLB VN	Date
Coimbatore	*	*	*	*	*	*	*	*	*	*	*	NA	18.1.08
Dharwad	*	*	*	*	*	*	*	*	*	*	*	*	24.12.07
Mauranipur	*	*	*	*	*	*	*	*	NA	NA	NA	NA	31.12.07
Palem	*	*	*	*	*	*	*	*	*	*	NA	NA	20.12.07
Pantnagar	*	*	*	*	*	*	*	*	*	NA	NA	NA	3.1.08
Parbhani	*	*	*	*	*	*	*	*	*	*	NA	NA	2.1.08
Akola	*	*	*	*	*	*	*	*	*	NA	NA	NA	1.2.08
Surat	NR	*	*	*	*	*	*	*	NA	NA	NA	NA	18.12.07
Udaipur	*	*	*	*	*	*	*	*	*	NA	NA	*	1.12.07

\*Reported; NR= Not reported; NA= Not allotted

## Annexure II: Details of collaborators

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## Appendix 1

### I. Diseases along with causal organisms under study

1. Grain molds *Fusarium moniliforme*, J. Sheld; *Curvularia lunata* *Phoma sorghina* & others.
2. Downy mildew *Peronosclerospora sorghi* (W. Weston & Uppal) C. G. Shaw
3. Ergot/Sugar disease *Sphacelia sorghi* Mc Rae
4. Charcoals rot *Macrophomina phaseolina* Tassi. Goindanich
5. Rust *Puccinia sorghi* Cooke
6. Anthracnose *Colletotrichum graminicola* (Ces G. W. Wils)
7. Leaf blight *Exserohilum turcicum*
8. Zonate leaf spot *Gloeocercospora sorghi* Bain & Edgerton ex Deighton
9. Rough leaf spot *Aschochyta sorghi* Sacc
10. Gray leaf spot *Cercospora sorghi* Ellis & Everh
11. Sooty stripe *Ramulispora sorghi* (Ellis & Everh) Olive & Lefebvre in Olive et. al.
12. Target leaf spot *Bipolaris sorghi* (Sacc) Shoemaker.

### II. Grades and estimation of Diseases:

**Grain molds** Field Grade (FG) and Threshed Grade (TG) recorded on 1-9 scale

Grade	Description	Reaction
1	No Spikelet infected with molds	Immune
2	1-5% of the panicle is affected by molds	Highly Resistant
3	6-10% of the panicle is affected by molds	Resistant
4	11-20% of the panicle is affected by molds	Moderately resistant
5	21-30% of the panicle is affected by spots	Moderately resistant
6	31-40% of the panicle is affected by molds	Moderately resistant
7	41-50% of the panicle is affected by molds	Moderately susceptible
8	51-75% of the panicle is affected by molds	Susceptible
9	>75% of the panicle is affected by molds.	Highly susceptible

**Foliar Diseases** (Rust, Sooty stripe, Zonate leaf spot, Leaf blight, Rough leaf spot, Target leaf spot)

Grade	Description	Reaction
1	No symptoms seen on the leaf and perfectly healthy	Immune
2	1-5% of the leaf area is affected by spots	Highly Resistant
3	6-10% of the leaf area affected by spots	Resistant
4	11-20% of the leaf area affected by spots	Moderately resistant
5	21-30% of the leaf area affected by spots	Moderately resistant
6	31-40% of the leaf area affected by spots	Moderately resistant
7	41-50% of the leaf area affected by spots	Moderately susceptible
8	51-75% of the leaf area affected by spots	Susceptible
9	>75% of the leaf area affected by spots	Highly susceptible

**Downy Mildew:** Number of plants infected out of total number of plants (Percent incidence) Ergot/ Sugar Disease/ Smut: on 1-9 scale

Grade	Description	Reaction
1	No Spikelet infected with molds	Immune
2	1-5% of the panicle is affected by molds	Highly Resistant
3	6-10% of the panicle is affected by molds	Resistant
4	11-20% of the panicle is affected by molds	Moderately resistant
5	21-30% of the panicle is affected by spots	Moderately resistant
6	31-40% of the panicle is affected by molds	Moderately resistant
7	41-50% of the panicle is affected by molds	Moderately susceptible
8	51-75% of the panicle is affected by molds	Susceptible
9	>75% of the panicle is affected by molds.	Highly susceptible

#### Charcoal rot:

1. Charcoal rot (%) i.e., Number of plants infected / total number of plants in a row.
2. Lodging due to charcoal rot (%)
3. Mean number of nodes crossed by the pathogen (numbers)
4. Mean length of spread of lesion (cm)

**Transformations:** All percentages are in arcsine transformations

**Threshed grade (TG):** Threshed grade is recorded on 1 to 5 scales as follows. The panicles will be threshed and a sample is taken in a Petri plate and the amount of surface area covered by the fungus is rated on 1 to 5 scale where 1= seed is white and no infection seen; 5 is > about 50% of the grain covered with mold fungi.