Sorghum pathology: Kharif 2015

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Executive summary

Pathology programme for the year 2015-16 consisted of applied as well as basic research components. Applied research dealt with multi-location testing of breeding materials for resistance against sorghum diseases at hot spot locations. A total 181 sorghum lines consisting of grain, forage and sweet sorghum entries were evaluated against panicle and foliar and systemic diseases in endemic areas (Palem, Coimbatore, Dharwad, Akola, Parbhani, Surat, Pantnagar and Ludhiana) spread over three sorghum growing zones. Basic and strategic research focused mainly grain mold, anthracnose and pokkah boeng.

Disease situations: Among panicle diseases grain mold was predominant in Tamil Nadu, Telangana, Karnataka, Gujarat and Maharashtra. Downy mildew was sporadic in Karnataka, Tamil Nadu and Gujarat and sugary disease (ergot) in Tamil Nadu. Among foliar diseases anthracnose, zonate and grey leaf spot appeared in moderate form in North India especially in forage growing regions. Leaf blight incidence was low and sporadic in Gujarat, Tamil Nadu and Karnataka. Rust was recorded in Marathwada region in Maharashtra and in Karnataka. Sporadic incidence of sooty stripe, rough, target and grey leaf spots was noted in Maharashtra and Punjab. In most host spots centres disease load was moderate as indicated by appearance of disease severity in susceptible checks as well as local checks.

Grain mold: Location severity index for grain mold assessed over all the trials in the location indicated that grain mold pressure was severe at Palem and Coimbatore, moderate at Akola and Surat and low at Parbhani. Grain mold severity ranged from 4.1 to 6.7 with mean 5.3 in grain sorghum (AHT, AVT, IHT and IVT), and 3.2 to 5.5 with mean 4.3 in sweet sorghum (IAVHT-SS). Among the advanced grain sorghum hybrids SPH 1777, SPH 1781, SPH 1778 and SPH 1773 and among the varieties SPV 2307, SPV 2305, SPV 2308 and SPV 2293 were moderately resistant to grain mold. Most promising entries in initial grain sorghum hybrid were SPH 1810, SPH 1821, SPH 1812 and SPH 1814 and varieties were SPV 2359, SPV 2370, SPV 2369, SPV 2360 and SPV 2371. Promising sweet sorghum entries for grain mold resistance were SPH 1755, SPV 2393 and SPV 2395.

Sugary disease/ Ergot: Moderate incidence of sugary disease was recorded from Coimbatore and Dharwad but not from any other locations. Incidence was highly sporadic and no significant differences were observed among the entries.

Downy mildew: One hundred and twenty-four grain, sweet and forage sorghum entries consisting of eight trials (AHT, AVT, IHT, IVT, IAVHT-SS, IAVHT-MC, AVHT-SC & IVHT-SC) were evaluated for downy mildew resistance in endemic locations. Location severity index indicated that downy mildew was moderate (5.6 to 9.0%) in Coimbatore, Dharwad and Surat. In Central and Northern India there was no report of downy mildew incidence. Among grain sorghum entries the advanced hybrids SPH 1776, SPH 1777 and SPH 1791 and the advanced varieties SPV 2296, SPV 2298 and SPV 2250 were promising for downy mildew resistance. Sweet sorghum entries SPV 2397 and SPV 2398 were promising for low SDM incidence.

Foliar diseases: Anthracnose, zonate leaf spot and grey leaf spot were major foliar diseases during kharif 2015. Location severity index showed that anthracnose severity was moderate to high at Pantnagar and Surat and low at Ludhiana and Coimbatore. Zonate leaf spot was moderate at Pantnagar. Grey leaf spot incidence was moderate at Ludhiana and low at Parbhani. Other foliar diseases like rough, gray leaf spot and sooty stripe were recorded as low incidence sporadically in a few locations. Most promising entries for foliar disease resistance were as follows; Grain sorghum hybrid- SPH 1781, SPH 1818, SPH 1778, SPH 1821, SPH 1775 and SPH 1811; varieties- SPV 2305, SPV 2371, SPV 2294, SPV 2296 and SPV 2365. Forage hybrid- SPH 1806, SPH 1752, SPH 1808; varieties- SPV 2312, SPV 2352, SPV 2376, SPV 2390, SPV 2378, SPV 2385 and SPV 2386 and sweet sorghum hybrid- SPH 1755 and SPH 2401; and varieties SPV 2393, SPV 2397 and SPV 2401.

Multiple resistances: In grain sorghum combined resistance against grain mold and downy mildew, grain mold and ergot and grain mold and foliar diseases are important for different growing locations. SPH 1777 and SPV 2298 were moderately resistant to grain mold and downy mildew, whereas SPH 1781 and SPV 2305 had combined resistant to grain mold and leaf diseases. Sweet sorghum hybrid SPH 1755 and variety SPV 2393 and SPV 2268 showed combined resistant to anthracnose and leaf blight. For forage varieties leaf disease resistance is of utmost importance. Multi-cut forage hybrid SPH 1806 had combined resistant to anthracnose and zonate leaf spot. Single-cut varieties SPV 2312, SPV 2376, SPV 2390 and SPV 2383 showed resistance to anthracnose and zonate leaf spot and SPV 2376 and SPV 2390 to anthracnose and grey leaf spot.

Grain mold pathogen variability: Fungal pathogen components varied over location and genotypes. Seven different fungal genera were detected including *Fusarium, Curvularia, Alternaria, Aspergillus, Bipolaris, Penicillium and Rhizopus* spp. *Fusarium* and *Curvularia* were major in frequency (>15%) while others were low (<5%). Among the entries the infection ranged from 13.8 (GMR 156-1) to 52.9 (CSH16) for *Fusarium*; 5.9 (GMR 156-1) to 24.4% (AKMGR 104) for *Curvularia*; 0.0 (AKMGR 101) to 12.5 (CSH23) for *Alternaria*; 0.0 (AKMGR 101) to 4.0 (B58586) for *Bipolaris*; and 0.2 (CSV 20) to 7.7 (GMR 166-1) for Aspergillus.

Grain mold nursery: In advance nursery entries R10-MP 13, GMR156-1, GMR83-1, AKMGR101, SU 1363 and PSVGS106 were resistant for PGS and TGS. Entries AKMGR 104, R 10-MP 13, GMR156-1, PSVGS106, SU 1363 and GMR124-1 recorded less than 20% *Fusarium* and *Curvularia* infection on grain. In initial nursery entries GMN14-6 was resistant and AKGMR111, GMN14-3, GMN14-9, GMN15-1, IS20956, IS21425, IS21645, IS23590, IS29314 and RMP42 were moderately resistant and highly promising.

Anthracnose resistant nursery: Five lines (IS 2095, ICSB 12021, IS 10302, IS 23521 and IS 473) out of 20 were at par in resistance with Pant Chari 5.

Screening technique development: Artificial screening technique for pokkah boeng disease was developed and refined. Stem injection produced highest disease incidence (43.5%) and severity index (26.4%) followed by whorl application (31.3%, 18.2%). The stem injection method was more stable than other methods of artificial inoculation. Studies on interrelationship among traits revealed that grain yield, plant height and earhead length were affected by the disease. This is the first instance where a suitable artificial inoculation method has been identified for screening sorghum genotypes for pokkah boeng resistance.

Pest and disease resistant nursery: Four entries (GMR 156, GMR 308, GMR 309 and NRCS-FR-09-3) were resistant to grain mold and others were moderately resistant. GMR 308 had mold resistance in bold seed (2.9g/100 seed). Mold resistance in these entries were combined with moderately resistant to anthracnose and zonate leaf spot.

Publications and recognitions: The AICRP-Sorghum Pathology group was involved in publishing 16 articles including eight journal papers and equal number of other publications during 2015-16. Scientists from different centres participated in national and international symposia. Dr IK Das, principal scientist and PI AICRP-Sorghum Pathology was awarded 'Fellow of Indian Phytopathological Society' at the 6th International Conference on 'Plant, Pathogens and Peoples, held on Feb. 23-27, 2016 in New Delhi.

Detailed report

I. Disease situations

During kharif season sorghum is usually grown for grain, forage as well as sweet stalks in different parts of India that are mainly located in the states of peninsular India (Tamil Nadu, Karnataka & Telangana), Central and Western India (Maharashtra, Parts of Gujarat Madhya Pradesh and Rajasthan) and in parts of North India (Uttarakhand, Uttar Pradesh, Haryana and Punjab). Type of sorghum diseases and their severity differ based on the type of sorghum grown. Report of the survey conducted on disease incidence in farmers' fields and in research plots at different sorghum growing regions in the country is as given below.

(A) Peninsular India

Tamil Nadu: Major diseases observed in this region were grain mold, downy mildew and sugary diseases. Apart from these, minor incidence of leaf anthracnose and rust were also noted. Grain mold severity grade varied from 2 to 9 with mean 5.5 (1-9 scale). Downy mildew incidence varied from 2 to 11 % and sugary disease 5 to 25 % on different sorghum. Grey leaf spot, zonate leaf spot and leaf blight incidence was negligible on few genotypes. Occurrence of rain during the late stage of the crop growth caused grain mold infection. Severe incidence of grain mold recorded in experimental materials. **Karnataka**: Because of humid weather the peninsular region attracts almost all the foliar and panicle diseases including grain mold, sugary disease, downy mildew, rust and leaf spot diseases on kharif sorghum. Downy mildew incidence was low to moderate (1.8 to 9.6%) on testing materials. Among the foliar diseases, the rust and zonate leaf spot were noted. **Telangana**: Grain mold was common in this region and incidence was medium to high in many areas. Mean grain mold incidence was moderate and low on locals. There was medium to high incidence of grain mold in the experimental trails. Incidence of foliar diseases viz., leaf blight, anthracnose and rust was low in local varieties. Bacterial soft rot

caused by *Erwinea chrysanthemi* was noted for the first time in low to moderated form in experimental plots in Hyderabad. In the experimental plot there was low incidence of leaf blight, anthracnose, downy mildew and chlorotic stripe virus.

(B) Central & Western States

Maharashtra: In Maharashtra disease incidence on grain sorghum was low to moderate. In Vidarbha region including Buldana, Wasim, Akola and Amravathi district low to moderate incidence of grain mold (2.0 to 5.0) was observed on local and improved cultivars in farmers' field. Among the foliar diseases leaf blight and sooty stripe appeared on some cultivars in minor form (2.0). Moderate incidence of leaf blight (3.8) was observed on sweet sorghum. In Marathawada region because of insufficient rainfall during consecutive years, grains were almost free from mold infection and incidence of foliar diseases like anthracnose and grey leaf spot was low. However, moderate incidence of rough leaf spot (4.0) was recorded on many local varieties and hybrids in Parbhani, Latur and Beed districts. **Gujarat:** Sorghum areas in south Gujarat received almost normal rainfall during this season and crop conditions were good. Disease survey in the different sorghum growing areas of the state indicated that the grain mold, sugary disease, anthracnose and leaf blight were more or less common (~3.5) diseases in this region. In south Gujarat, grain mold and sugary disease were observed in moderate form on farmers' field. Under experimental conditions also these diseases appeared in moderate form along with downy mildew (~9%). **Rajasthan:** Forage as well as dual purpose sorghum is grown in this area. Moderate to severe infection of anthracnose, zonate leaf spot, gray leaf spot and traces to moderate incidence of leaf blight, target leaf spot and rusts, are observed on local land races of sorghum cultivars.

(C) Northern States

Punjab: The region is known for sorghum as forage crop and presence of high humidity attracts lot of foliar disease on this crop. During kharif 2015 major leaf diseases observed were grey leaf spot, anthracnose and zonate leaf spot. Dominating leaf spot disease was grey leaf spot caused by *Cercospora sorghi*. Anthracnose caused by *Colletotrichum* spp. was observed on stalks but per cent was less than 5.0. Zonate leaf spot was observed in traces due to prevailing less humid conditions because of few rains. **Uttarakhand**: Disease situation was surveyed on several places in farmers' field in the districts of Dehradun, Nainital, US Nagar and Hardwar districts on improved and local cultivars, which are mostly grown for forage purpose. Anthracnose and zonate leaf spot were two major diseases in this region. Severity of these diseases was more on local (6.0 to 7.5) than improved cultivars (4.0 to 5.5. These two diseases along with target leaf spot occurred in moderate to severe intensity (grade 5 – 7.5) in almost all the genotypes grown in farmers' field. In brief, among panicle diseases grain mold was predominant in Tamil Nadu, Telangana and Gujarat. Sugary disease (ergot) was Tamil Nadu and Karnataka. Downy mildew in low to moderate form was noted in peninsular region. Among foliar diseases anthracnose, zonate leaf spot appeared in moderate to severe form in Pantnagar, and grey leaf spot in Ludhiana. Leaf blight, rust was recorded in Coimbatore, and sporadically in Marathwada region of Maharashtra. Sporadic incidence of sooty stripe, rough, target and grey leaf spots was also noted in Parbhani and Akola, region. Location severity index (LSI) for various diseases indicated that materials under evaluation exhibited presence of some degree of resistance against diseases.

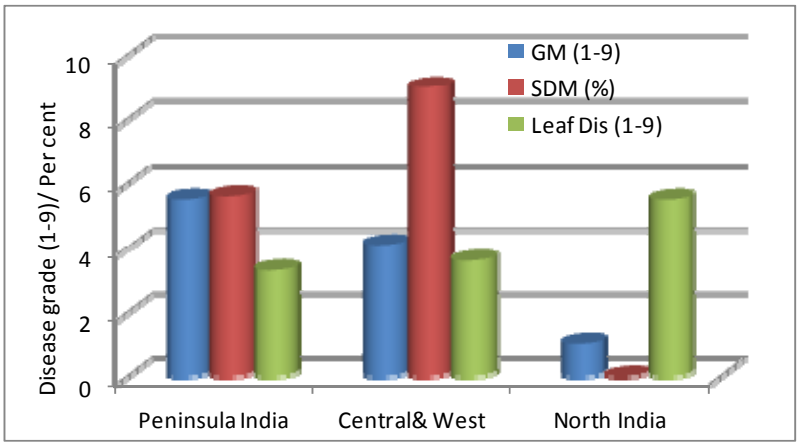

Table S1: Summaries of disease situation in sorghum growing states

States	Grain mold (1-9)	Downy mildew (%)	Sugary Disease (%)	Leaf diseases (1-9)	Dominant leaf diseases
Tamil Nadu	6.1	5.6	13	3.5	Anthracnose
Karnataka	5.0	5.6	Traces	3.2	Leaf blight
Telangana	5.5	Traces	Traces	3.3	Anthracnose & Zonate
Maharashtra	3.5	nr	nr	3.1	Sooty & Rough leaf spot
Gujarat	4.6	9	nr	4.0	Anthracnose & Leaf blight
Uttarakhand	nr	nr	nr	6.0	Anthracnose & Zonate leaf spot
Punjab	nr	nr	nr	5.0	Grey leaf spot

II. Evaluation of grain sorghum experimental varieties/ hybrids/ parental lines for resistance to major diseases

Seventy-three grain sorghum entries (excluding checks) consisting of advanced and initial experimental hybrids and varieties in four trials (Advanced Hybrid Trial, Advanced Varietal Trial, Initial Hybrid Trial and Initial Varietal Trial) were evaluated for resistance to grain mold, downy mildew and foliar diseases in hot spot locations under natural conditions in Zone I (Coimbatore, Pantnagar & Palem) and Zone II (Akola, Parbhani, Surat & Dharwad) along with susceptible and resistant checks for different diseases. Panicle grain mold score (PGS) and threshed grain mold score (TGS) were recorded using 1-9 rating scale, where 1 = no mold and 9= >75% mold infected grains in Zone I and Zone II. Location severity index (LSI) for grain mold assessed over all the trials in the location indicated that grain mold pressure was moderate across locations and foliar disease pressure was high at moderate at Pantnagar.

Table S2: Grain mold severity index for different locations (LSI)

Location	AHT	AVT	IHT	IVT	LSI	Max Score	Total observations
Palem	6.3	6.5	5.8	6.0	**6.1**	9.0	101
Coimbatore	7.0	6.0	6.4	6.3	**6.4**	9.0	101
Parbhani	1.9	1.3	1.7	1.4	**1.5**	6.0	185
Akola	3.5	3.3	3.4	3.3	**3.2**	6.3	185
Surat	5.0	5.3	2.8	3.9	**4.6**	7.0	167

1. Advanced Hybrid Trial (AHT-GS)

AHT-GS trial was comprised of total 23 entries. They included 10 test entries, five hybrid checks, one local check from respective centre and seven pathology checks for comparing disease reactions.

Grain mold: Grain mold was recorded at five centres namely Palem, Coimbatore (Zone I), Akola, Parbhani & Surat (Zone II). Location severity index (LSI) for grain mold were 6.1 (Palem), 5.5 (Coimbatore), 3.2 (Akola), 1.4 (Parbhani), and 4.6 (Surat) for PGS and 5.8 (Palem), 3.8 (Coimbatore), 3.5 (Akola), 2.4 (Parbhani), and 4.4 (Surat) for TGS.

Panicle grain mold (PGS): Average data over the locations showed that PGS ranged from 2.1 to 7.3 (resistance to susceptible reaction). Location means were 6.4 (Palem), 7.3 (Coimbatore), 3.6 (Akola), 2.1 (Parbhani), and 5.1 (Surat). Location means were 6.6 (Palem), 6.4 (Coimbatore), 3.3 (Akola), 1.4 (Parbhani), and 5.3 (Surat). **Zone I-** Trials were laid at two centres and disease pressure was quite high. At Coimbatore, location severity index (LSI) was 5.5 where susceptible check scored 8.0. All entries were at par with the hybrid and local checks. At Palem, location severity index (LSI) was 6.1 where susceptible check scored 8.5. All entries were at par with the hybrid and local checks. **Zone II-** In zone II trials were conducted at Parbhani, Akola, Dharwad and Surat. Due to very late sowing mold data was not received from Dharwad. Disease pressure was moderate at Surat (5.1) and Akola (3.6). At Parbhani incidence was low (mean 2.1) hence data were not considered for national average. Mold reactions of entries significantly differed at these locations. Pooled analysis of Surat and Akola data showed that performance of entries in zone-II were not significantly different from each other and they were all moderately resistance. **National-** As zone-I experienced high disease pressure pooled analysis over locations indicated that the entries were susceptible in zone-I and moderately resistance in Zone-II. Best performing hybrid CSH 14 scored 5.3 and all the entries were at par with CSH 14 (moderately resistant). Top ranked three entries were SPH 1777, SPH 1778, and SPH 1781 (Table 1.1).

Threshed grain mold (TGS): Average data over the locations showed that TGS ranged from 3.6 to 6.1 (moderately resistance to susceptible reaction). **Zone I-** Trials were laid at two centres and disease pressure was

moderate to high. At Coimbatore, location severity index (LSI) was 3.8 where susceptible check scored 4.7. Due to low score in susceptible check data was not included in national mean. All entries were at par with the hybrid checks. At Palem, location severity index (LSI) was 5.8 where susceptible check scored 8.2. All entries were at par with the hybrid and local checks. **Zone II-** In zone II trials were conducted at Parbhani, Akola, Dharwad and Surat. Disease pressure was moderate at Surat (4.7) Parbhani (4.2) and Akola (3.6). Mold reactions of entries significantly differed at these locations. Pooled analysis of Surat and Akola data showed that performance of entries in zone-II were significantly different from each other and they were resistant to moderately resistance. **National-** Data from two zones consisting of four centres indicated that except CSH 23, all other entries and hybrid checks were at par in resistance to TGS. Best performing hybrid CSH 30 scored 4.1 and all the entries were at par with CSH 14 (moderately resistant). Top ranked three entries were SPH 1789, SPH 1773, and SPH 1781 (Table 1.1).

Seed mycoflora: Studies of seed mycoflora of the harvested grain give an account of seed-borne microorganisms including grain mold fungi. Seed mycoflora studies were carried out on harvested grains at Coimbatore, Palem, Parbhani, Akola and Surat centres (Table 1.2). Frequency of infection of major grain mold fungi like *Fusarium* and *Curvularia* was estimated. Frequencies of *Fusarium* infection at different locations were 28.2% (Palem), 17.8% (Coimbatore), 22.7% (Parbhani), 18.4% (Akola) and 14.1% (Surat) and that of *Curvularia* was 18.4% (Palem), 38.3% (Coimbatore), 20.4% (Parbhani), 22.4% (Akola) and 32.8% (Surat). *Fusarium* infection significantly differed among the entries in Parbhani, Akola and Surat locations *Curvularia* infection in Surat location. On national average Fusarium infection ranged from 12.0% (B58586) to 31.0% (296B) and *Curvularia* infection from 19.0% (B58586) to 33.0% (BulkY). Among the test entries *Fusarium* infection was less on SPH 1779, SPH 1780 and SPH 1781 (17.2 to 17.9%) and *Curvularia* on SPH 1773, SPH 1777 and SPH 1775 (22.7 to 23.5%). Data from two zones consisting of three centres indicated that SPH 1777 was least affected by seed borne infection of mycoflora (20.9%).
Based on results of PGS, TGS and seed mycoflora studies SPH 1777 and SPH 1781 were found promising for grain mold resistance.

Downy mildew: Incidence of downy mildew was recorded in percentage. Standard method of resistance grading [i.e. R =≤5%; MR=6-10% S= 11-30%; HS=≥30%] was followed. Downy mildew was reported from peninsular India *viz*., Coimbatore, Dharwad and also from Surat with mean incidence 5.9%, 1.8% and 6.4% respectively. Downy mildew data from Dharwad and Surat were not included because of high coefficient of variation (CV) even after data transformation. At Coimbatore location entries differed significantly on downy mildew reactions with susceptible check recording 11.3% incidence. Except SPH 1779, all other entries were resistant to moderately resistant to downy mildew (Table 1.4). Top five entries were SPH 1776, SPH 1791, CSH16, SPH 1777 and CSH 30 [2.0 to 4.8%].

Sugary disease or ergot: Ergot Incidence was recorded in percentage (where, up to 10% resistant; 11-30% moderately resistant; 31-50% susceptible; and >50% highly susceptible). Moderate to high incidence of sugary disease was recorded from Coimbatore and Dharwad but not from any other locations. Showing of the trials in these two locations was very late (27 July & 8 August), which might have caused pollen starving and the resultant incidence. Data not included because of high CV.

Foliar diseases: AHT entries were evaluated for foliar disease resistance under artificial/natural conditions in hot spots (Pantnagar, Surat and Coimbatore) locations. The disease severity was scored on a 1-9 rating scale. Anthracnose and zonate leaf spot were moderate in incidence. Minor and sporadic incidence of other leaf diseases including leaf blight, grey leaf spot, rough leaf spot and sooty stripe was noted in one or other locations.

Anthracnose: Anthracnose was recorded in Pantnagar, Surat and Coimbatore (Table 1.4). Disease pressure was moderate at Pantnagar (4.9) and low-moderate at Coimbatore (3.5) and Surat (3.0). Disease reactions of the entries significantly differed at Pantnagar location. All entries showed moderately resistant reactions (except the Local check, which were susceptible), with respect to the resistant check 296B/ Pant Chari 5 (4.5). Five top ranked entries were SPH 1781, SPH 1779, SPH 1791, SPH 1776 and SPH 1789 [2.7 to 3.2].

Zonate leaf spot: The disease was recorded in Pantnagar in moderate form (5.0) (Table 1.3) and in Parbhani as traces (data not included). No other centre reported the disease this year. The entries differed significantly on resistance and SPH 1778 (4.3) was the best performing entry. Five top ranked entries were SPH 1778, SPH 1775, SPH1789, SPH 1777 and SPH 1776 [4.3 to 4.8].

Leaf blight: Occurrence of leaf blight was reported from Akola, Surat and Coimbatore. Disease incidence was low in all the above locations and entries behaved as resistance. Top five low scoring entries were SPH 1775, SPH 1781, SPH 1773, SPH 1779 and SPH 1789 [1.3 to 1.8] (Table 1.4).

Time to flowering: Days to 50% flowering was recorded at Parbhani, Akola, Surat and Dharwad. Location means varied from 61.5 (Surat) to 76.6 (Akola) days with national mean 68.4 days (Table 1.3). Data was significant at 5% level across locations except Dharwad. Among the test entries SPH 1777 was the earliest (65 days) and SPH 1775 was the latest (72 days) to flower.

Plant height: Plant height was recorded at Coimbatore and Dharwad. Mean plant height in these locations was 168.7cm (Coimbatore) and 137.5cm (Dharwad) (Table 1.3). Data was significant at 5% level across locations. Among the test entries SPH 1781 was the shortest (136cm) and SPH 1776 was the tallest (176cm) in height.

Germination and seed weight: Germination ability of seed was tested in Palem, Coimbatore, Parbhani, Akola and Surat centres (Table 1.3). Germination ranged from 35.7% (Palem) to 77.5% (Akola) with national mean 53.8%. Data was significant at 5% level across locations except Surat. Among the test entries germination was highest in SPH 1773 and SPH 1789 (56%) and lowest in SPH 1775 and SPH 1776 (51%). Seed weight was recorded at Akola & Coimbatore and entries differed significantly in these locations (range 2.2 to 3.1). All the test entries wear at par with the checks (Table 1.3). SPH 1778, SPH 1787 and CSH 16 had 100 seed weight ≥3.0.

2. Advanced Varietal Trial (AVT-GS)

AVT-GS trial was comprised of total 21 entries. They included 9 test entries, four varietal checks, one local check from respective centre and seven pathology checks for comparing disease reactions.

Grain mold: Grain mold: Grain mold was recorded at five centres namely Palem, Coimbatore (Zone I), Akola, Parbhani & Surat (Zone II). Location severity index (LSI) for grain mold were 6.1 (Palem), 5.5 (Coimbatore), 3.2 (Akola), 1.4 (Parbhani), and 4.6 (Surat) for PGS and 5.8 (Palem), 3.8 (Coimbatore), 3.5 (Akola), 2.4 (Parbhani), and 4.4 (Surat) for TGS.

Panicle grain mold (PGS): Average data over the locations showed that PGS ranged from 1.4 to 6.6 (resistance to susceptible reaction). Location means were 6.6 (Palem), 6.4 (Coimbatore), 3.3 (Akola), 1.4 (Parbhani), and 5.3 (Surat). **Zone I-** Trials were laid at two centres and disease pressure was quite high. At Coimbatore, location severity index (LSI) was 5.5 where susceptible check scored 7.1. At Palem, location severity index (LSI) was 6.1 where susceptible check scored 8.6. In zone-I test was significant at 5% level but test entries were not significantly different and at par with the varietal and local checks (Table 2.1). **Zone II-** In zone II trials were conducted at Parbhani, Akola, Dharwad and Surat. Due to very late sowing mold data was not received from Dharwad. Disease pressure was moderate at Surat (5.3) and Akola (3.3). At Parbhani incidence was low (mean 1.4) hence data were not considered for national average. Mold reactions of entries significantly differed at Akola and Surat but not at Parbhani. Pooled analysis of Surat and Akola data showed that test was significant at 5% level only due to resistant the check, otherwise, entries in zone-II were not significantly different from each other and from the varietal and local checks. **National-** As zone-I experienced high disease pressure pooled analysis over locations indicated that the entries were susceptible in zone-I and moderately resistance in Zone-II. Best performing variety CSV 23 scored 5.1 and all the entries were at par with it (moderately resistant). Top ranked three test entries were SPV 2307, SPV 2308, and SPV 2305 (Table 2.1).

Threshed grain mold (TGS): Average data over the locations showed that TGS ranged from 2.5 to 6.3 (resistance to susceptible reaction). **Zone I-** Trials were laid at two centres and disease pressure was moderate to high. At Coimbatore, location severity index (LSI) was 3.8 where susceptible check scored 4.7. Due to low score in susceptible check data was not included in national mean. SPV 2294 was susceptible at Coimbatore. All other entries were at par with the varietal checks (Table 2.1). At Palem, location severity index (LSI) was 5.8 where susceptible check scored 8.3. Entry SPV 2296, SPV 2298 and SPV 2299 were susceptible at Palem and other entries were at par with the variety and local checks. Overall in zone-I, entries were not significantly different. **Zone II-** In zone II trials were conducted at Parbhani, Akola, Dharwad and Surat. Disease pressure was moderate at Surat (4.7) and Akola (3.7) and low at Parbhani (2.5). Parbhani centre data was excluded from national mean due to high CV (>25%). Mold reactions of entries significantly differed at Akola and Surat. Pooled analysis of data showed that performance of entries in zone-II was not significantly different from each other and they were moderately resistant type. **National-** Data from two zones consisting of three centres indicated that all

the entries and varietal checks were at par for resistance to TGS. Best performing variety CSV 20 scored 4.7 and was moderately resistant. Top ranked three test entries were SPV 2307, SPV 2299 and SPV 2305 (Table 2.1).

Seed mycoflora: Studies of seed mycoflora were carried out on harvested grains at Coimbatore, Palem, Parbhani, Akola and Surat centres (Table 2.2). Frequency of infection of major grain mold fungi like *Fusarium* and *Curvularia* was estimated. Frequencies of *Fusarium* infection at different locations were 37.4% (Palem), 33.0% (Coimbatore), 38.3% (Parbhani), 18.9% (Akola) and 24.7% (Surat) and that of *Curvularia* was 16.8% (Palem), 16.5% (Coimbatore), 21.3% (Akola) and 25.8% (Surat). *Fusarium* infection significantly differed among the entries in Parbhani, Akola and Surat locations *Curvularia* infection in Akola and Surat locations. On national average Fusarium infection ranged from 13.0% (B58586) to 39.3% (296B) and *Curvularia* infection from 15.5% (SPV 2305) to 25.5% (BulkY). Among test entries *Fusarium* infection was less on SPV 2308, SPV 2307 and SPV 2298 (26.2 to 30.5%) and *Curvularia* on SPV 2305, SPV 2307 and SPV 2308 (15.5 to 18.8%). Data from two zones consisting of three centres indicated that SPV 2308 (22.5%) and SPV 2307 (22.8%) were least affected by seed borne infection of mycoflora.
Based on results of PGS, TGS and seed mycoflora studies SPV 2307, SPV 2305 and SPV 2308 were found promising for grain mold resistance.

Downy mildew: Downy mildew was reported from peninsular India *viz*., Coimbatore, Dharwad and also from Surat with mean incidence 10.2%, 9.8% and 4.8% respectively in AVT. Incidence was highly sporadic resulting in high coefficient of variations (CV) even after data transformation. Incidence ranged from 2 to 10% among the test entries and the varietal and local checks, indication resistant to moderately resistant reactions (Table 2.4). Top three test SPV 2296, SPV 2298, and SPV 2308 [3.3 to 5.0%].

Sugary disease or ergot: Moderate to high incidence of sugary disease incidence was recorded from Coimbatore and Dharwad but not from any other locations. Showing of the trials in these two locations was very late (27 July & 8 August), which might have caused pollen starving and the resultant incidence. Data not included because of high CV.

Foliar diseases: AVT entries were evaluated for foliar disease resistance under artificial/natural conditions in hot spots (Pantnagar, Surat and Coimbatore) locations. The disease severity was scored on a 1-9 rating scale. Anthracnose and zonate leaf spot were moderate in incidence. Minor and sporadic incidence of other leaf diseases including leaf blight, grey leaf spot, rough leaf spot and sooty stripe was noted in one or other locations.

Anthracnose: Anthracnose was recorded in Pantnagar, Surat (Table 2.3) and sporadically in a few entries in Coimbatore. Disease pressure was moderate at Pantnagar (4.9) and low-moderate at Surat (3.3). Disease reactions of the entries significantly differed at Pantnagar but not at Surat location. On national mean entries showed moderately resistant reactions to anthracnose. Three top ranked entries were SPV 2305, SPV 2294 and SPV 2293 [3.8 to 3.8].

Zonate leaf spot: The disease was recorded only in Pantnagar in moderate form (5.0) (Table 2.3). The entries differed significantly on resistance and CSV 27 (4.2) was the best performing entry. Three top ranked test entries were SPV 2294, SPV 2293 and SPV 2296 [4.0 to 4.7].

Leaf blight: Occurrence of leaf blight was reported from Surat in moderate form (3.3) and from Akola and Coimbatore in traces. Top three low scoring entries were SPV 2296, SPV 2298 and SPV 2305 [2.3 to 3.3] (Table 2.4).

Time to flowering: Days to 50% flowering was recorded at Parbhani, Akola, Surat and Dharwad and Coimbatore. Location means varied from 60.6 (Coimbatore) to 81.4 (Akola) days with national mean 69.6 days (Table 2.3). Data was significant at 5% level across locations except Parbhani. Among the test entries SPV 2298 was the earliest (67 days) and SPV 2305 was the latest (73 days) to flower.

Plant height: Plant height was recorded at Coimbatore and Dharwad. Mean plant height in these locations was 198.9cm (Coimbatore) and 150.15cm (Dharwad) (Table 2.3). Data was significant at 5% level across locations. Among the test entries SPV 2298 was the shortest (116cm) and SPV 2299 was the tallest (190cm) in height.

Germination and seed weight: Germination ability of seed was tested in Palem, Coimbatore, Parbhani and Akola centres (Table 2.2). Germination ranged from 32.2% (Palem) to 76.5% (Akola) with national mean 55.5%.

Data was significant at 5% level across locations except Coimbatore and Akola. Among the test entries germination was highest in SPV 2307 (60%) and lowest in SPV 2298 (48%). Seed weight was recorded at Akola, Palem and Coimbatore and entries differed significantly at Akola and Coimbatore. Among the test entries seed weight varies from 2.2 to 3.0g for 100 seed (Table 2.4). SPV 2307 had 100 seed weight ≥3.0.

3. Initial Hybrid Trial (IHT-GS)

IHT-GS trial was comprised of total 25 entries. They included 12 test entries, five hybrid checks, one local check from respective centre and seven pathology checks for comparing disease reactions.

Grain mold: Grain mold was recorded at five centres namely Palem, Coimbatore (Zone I), Akola, Parbhani & Surat (Zone II). Location severity index (LSI) for grain mold were 6.1 (Palem), 5.5 (Coimbatore), 3.2 (Akola), 1.4 (Parbhani), and 4.6 (Surat) for PGS and 5.8 (Palem), 3.8 (Coimbatore), 3.5 (Akola), 2.4 (Parbhani), and 4.4 (Surat) for TGS.

Panicle grain mold (PGS): Average data over the locations showed that PGS ranged from 2.1 to 6.7 (resistance to susceptible reaction). Location means were 5.8 (Palem), 6.8 (Coimbatore) and 3.5 (Akola). Parbhani data was not included for low disease pressure and Surat data for high CV. **Zone I-** Data from two centres were included for analysis and disease pressure was quite high and susceptible checks scored 7.3 to 8.7 (Table 3.1). At Coimbatore, all entries were at par with the hybrid and local checks and all showed susceptibility due to high disease pressure. At Palem, all entries were at par with the hybrid and local checks. **Zone II-** In zone II data from Akola was included for analysis. Due to very late sowing mold data was not received from Dharwad. Mold reactions of entries significantly differed at Akola. **National-** As zone-I experienced high disease pressure pooled analysis over locations indicated that the entries were susceptible in zone-I and resistant to moderately resistance in Zone-II. All the test hybrids and the checks were at par. Top ranked three entries were SPH 1810, SPH 1821, and SPH 1814 (4.6 to 5.1).

Threshed grain mold (TGS): Average data over the locations showed that TGS ranged from 3.8 to 5.4 (moderately resistance to susceptible reaction). Location means were 5.4 (Palem), 4.4 (Coimbatore), 3.8 (Akola) and 4.4 (Surat) (Table 3.1). Parbhani data was not included for low disease pressure. **Zone I-** Data from two centres were considered for inclusion and entries were different at 5% level. At Coimbatore, entries were resistant to moderately resistant range whereas in Palem they were at moderately resistant range [except CSH 14 (6.3) and CSH (7.0); susceptible]. **Zone II-** Disease pressure was moderate at Surat (4.4) and Akola (3.8). Mold reactions of entries significantly differed at these locations. Pooled analysis of data showed that mold reactions of entries were significantly different from each other and they were resistant to moderately resistance. **National-** Data from two zones consisting of four centres indicated that except CSH 23, all other entries and hybrid checks were at par in resistance to TGS. Best performing hybrid CSH 25 scored 4.6 and all the entries were at par with it (moderately resistant). Top ranked three entries were SPH 1810, SPH 1814 and SPH 1812 (3.4 to 3.8).

Seed mycoflora: Seed mycoflora studies were carried out on harvested grains at Palem, Parbhani, Akola and Surat centres (Table 3.2). Frequency of infection of major grain mold fungi like *Fusarium* and *Curvularia* was estimated. Frequencies of *Fusarium* infection at different locations were 26.5% (Palem), 22.3% (Parbhani), 18.7% (Akola) and 16.4% (Surat) and that of *Curvularia* was 20.0% (Palem), 20.9% (Parbhani), 21.1% (Akola) and 25.3% (Surat). *Fusarium* infection significantly differed among the entries in Parbhani, Akola and Surat locations and *Curvularia* infection in Surat location. On national average *Fusarium* infection ranged from 11.8% (B58586) to 33.5% (296B) and *Curvularia* infection from 12.2% (B58586) to 30.2% (BulkY). Among the test entries *Fusarium* infection was relatively less on SPH 1821, SPH 1812 and SPH 1814 (17.2 to 17.4%) and *Curvularia* on SPH 1812, SPH 1810 and SPH 1814 (13.6 to 17.4%). Data from two zones consisting of four centres indicated that SPH 1812 was least affected by seed borne infection of mycoflora (15.6%).
Based on results of PGS, TGS and seed mycoflora studies SPH 1810, SPH 1812 and SPH 1814 were found promising for grain mold resistance.

Downy mildew: Downy mildew was reported from peninsular India *viz*., Coimbatore, Dharwad and also from Surat with mean incidence 5.3%, 4.3% and 5.0% respectively. Incidence was highly sporadic and data were not considered because of high coefficient of variation (CV) even after data transformation. Range was 1.6 to 13.2% among test entries and hybrid checks. Top five test entries with respect to fewer incidences were SPH 1813, SPH 1821, SPH 1816, SPH 1817 and SPH1812 (2.9 to 3.1%) (Table 3.4).

Sugary disease or ergot: Moderate to high incidence of sugary disease was recorded from Coimbatore and Dharwad but not from any other locations. Data not included because of high CV.

Foliar diseases: IHT entries were evaluated for foliar disease resistance under artificial/natural conditions in hot spots (Pantnagar, Surat and Coimbatore) locations. The disease severity was scored on a 1-9 rating scale. Anthracnose and zonate leaf spot were moderate in incidence. Minor and sporadic incidence of other leaf diseases including leaf blight, grey leaf spot, rough leaf spot and sooty stripe was noted in one or other locations.

Anthracnose: Anthracnose was recorded in Pantnagar, Surat (Table 3.4). Disease pressure was moderate at Pantnagar (4.9) and low-moderate Surat (3.3). Disease reactions of the entries significantly differed at both locations. All entries showed moderately resistant reactions on national mean. Five top ranked entries were SPH 1818, SPH 1821, SPH 1811, SPH 1813 and SPH 1820 [3.3 to 3.8].

Zonate leaf spot: The disease was recorded in Pantnagar in moderate form (4.5) and in Parbhani as traces (data not included). No other centre reported the disease this year. The entries differed significantly on resistance and SPH 1821 (4.0) was the best performing entry. Five top ranked entries were SPH 1821, SPH 1817, SPH 1815, SPH 1811 and SPH 1819 [4.0 to 4.3].

Leaf blight: Occurrence of leaf blight was reported from Akola and Surat. Disease incidence was low in all the above locations and entries behaved as resistance. Top five low scoring entries were SPH 1811, SPH 1814, SPH 1815, SPH 1818 and SPH 1820 [1.8 to 2.2] (Table 3.4).

Time to flowering: Days to 50% flowering was recorded at Parbhani, Akola, Surat and Dharwad. Location means varied from 62.8 (Surat) to 78.3 (Akola) days with national mean 69.3 days (Table 3.3). Data was significant at 5% level across locations except Parbhani (non-significant). Among the test entries SPH 1815 was the earliest (67.1 days) and SPH 1810 was the latest (74.4 days) to flower.

Plant height: Plant height was recorded at Dharwad. Mean plant height in the location was 139.1cm (Table 3.3). Data was significant at 5% level. Among the test entries SPH 1811 was the shortest (133.3cm) and SPH 1821 was the tallest (190cm) in height.

Germination and seed weight: Germination ability of seed was tested in Palem, Parbhani, Akola and Surat centres (Table 3.3). Germination ranged from 23.6% (Surat) to 78.2% (Akola) with national mean 53.0%. Data was significant at 5% level at Palem and Akola. Among the test entries germination was highest in SPH 1812 (57.5%) and lowest in SPH 1811 (48.6%). Test weight of grain was recorded at Akola and Palem and entries differed significantly in Akola but not in Palem. Seed weight varied from 2.5 to 3.2g/100 seed among the test entries and 2.8 to 2.9 among the hybrid checks (Table 3.3). SPH 1819, SPH 1816 and SPH 1812 had 100 seed weight more than 3.0.

4. Initial Varietal Trial (IVT-GS)

IVT-GS trial was comprised of total 32 entries. They included 20 test entries, four varietal checks, one local check from respective centre and seven pathology checks for comparing disease reactions.

Grain mold: Grain mold: Grain mold was recorded at five centres namely Palem, Coimbatore (Zone I), Akola, Parbhani & Surat (Zone II). Location severity index (LSI) for grain mold 6.1 (Palem), 5.5 (Coimbatore), 3.2 (Akola), 1.4 (Parbhani), and 4.6 (Surat) for PGS and 5.8 (Palem), 3.8 (Coimbatore), 3.5 (Akola), 2.4 (Parbhani), and 4.4 (Surat) for TGS.

Panicle grain mold (PGS): Average data over the locations showed that PGS ranged from 3.3 to 6.6 (moderately resistance to susceptible reaction). Location means were 5.9 (Palem), 6.6 (Coimbatore), 3.3 (Akola), and 3.8 (Surat). **Zone I-** Disease pressure was quite high at both the locations and susceptible check scored 6.0-8.2 and differences among the entries were significant at 5% level. Test entries were not significantly different and at par with the varietal and local checks (Table 4.1). **Zone II-** In zone II trials were conducted at Parbhani, Akola, Dharwad and Surat. Due to very late sowing mold data was not received from Dharwad. At Parbhani incidence was low (mean 1.4) hence data were not considered for national average. Disease pressure was moderate to low at Surat (3.8) and Akola (3.3) and mold reactions of entries significantly differed. Pooled analysis of Surat and Akola data showed that test was significant at 5% level. **National-** As zone-I experienced relatively high disease pressure pooled analysis over locations indicated that the entries were susceptible in zone-I and

moderately resistance in Zone-II. Best performing variety CSV 20 and CSV 23 scored 4.4 and all the entries were at par with it (moderately resistant). Top ranked three test entries were SPV 2370, SPV 2359, SPV 2369, SPV 2371 and SPV 2360 (4.1 to 4.5) (Table 4.1).

Threshed grain mold (TGS): Average data over the locations showed that TGS ranged from 3.5 to 5.6 (moderately resistance to susceptible reaction). Location means were 5.6 (Palem), 5.0 (Coimbatore), 3.6 (Akola), and 3.5 (Surat). **Zone I-** Trials were laid at two centres and disease pressure was moderate and entries differed at 5% level of significance in both location (Table 4.1). Seven test entries scored less than 5.0 in Palem and 8 entries scored same in Coimbatore. SPV 2367 and SPV 2372 scored susceptible reactions along with the check CSV 17. Most of the entries in zone-II were moderately resistant. **Zone II-** In zone II trials were conducted at Parbhani, Akola, Dharwad and Surat. Parbhani centre data was excluded from national mean due to high CV (>25%). Disease pressure was moderate at Surat and Akola and mold reactions of entries significantly differed at both these locations. Entries were resistant to moderately resistant in this zone. **National-** Data from two zones consisting of four centres indicated that all the entries and varietal checks were at par for resistance to TGS. Top ranked five test entries were SPV 2359, SPV 2370, SPV 2369, SPV 2362 and SPV 2371 (3.6 to 4.1) (Table 4.1).

Seed mycoflora: Studies of seed mycoflora were carried out on harvested grains at Coimbatore, Palem, Parbhani, Akola and Surat centres (Table 4.2). Frequency of infection of major grain mold fungi like *Fusarium* and *Curvularia* was estimated. Frequencies of *Fusarium* infection at different locations were 27.8% (Palem), 18.0% (Coimbatore), 21.6% (Parbhani), 18.2% (Akola) and 15.7% (Surat) and that of *Curvularia* was 17.8% (Palem), 34.9% (Coimbatore), 13.1% (Parbhani), 21.0% (Akola) and 15.4% (Surat). *Fusarium* infection significantly differed among the entries in Palem, Akola and Surat locations *Curvularia* infection in Palem and Surat locations. On national average *Fusarium* infection ranged from 12.2% (B58586) to 26.1% (296B) and *Curvularia* infection from 15.3% (B58586) to 31.8% (BulkY). Among test entries *Fusarium* infection was relative less on SPV 2369, SPV 2361 and SPV 2364 (15.0 to 17.3%) and *Curvularia* on SPV 2367, SPV 2359 and SPV 2370 (16.7 to 18.3%). Data from two zones consisting of three centres indicated that SPV 2367 (17.0%) and SPV 2367 (17.8%) were least affected by seed borne infection by of *Fusarium* and *Curvularia*. Based on results of PGS, TGS and seed mycoflora studies SPV 2359, SPV 2369 and SPV 2370 were found promising for grain mold resistance.

Downy mildew: Downy mildew was reported from peninsular India *viz*., Coimbatore, Dharwad and also from Surat with mean incidence 6.6%, 6.4% and 7.9% respectively in IVT. Incidence was highly sporadic in nature resulting in high coefficient of variations (CV) even after data transformation. Incidence ranged from 1.0 to 13.0% among the test entries and the varietal and local checks, indication resistant to moderately resistant reactions (Table 4.5). Top five test entries with respect to fewer incidences were SPV 2373, SPV 2355, SPV 2359, SPV 2364 and SPV 2358 [2.6 to 4.2%].

Sugary disease or ergot: Moderate to high incidence of sugary disease incidence was recorded from Coimbatore and Dharwad but not from any other locations. Showing of the trials in these two locations was very late (27 July & 8 August), which might have caused pollen starving and the resultant incidence. Data not included because of high CV.

Foliar diseases: IVT entries were evaluated for foliar disease resistance under artificial/natural conditions in hot spots (Pantnagar, Surat and Coimbatore) locations. The disease severity was scored on a 1-9 rating scale. Anthracnose and zonate leaf spot were moderate in incidence. Minor and sporadic incidence of other leaf diseases including leaf blight, grey leaf spot, rough leaf spot and sooty stripe was noted in one or other locations.

Anthracnose: Anthracnose was recorded in Pantnagar, Surat (Table 4.4) and sporadically in a few entries in Coimbatore. Disease pressure was moderate at Pantnagar (4.9) and low at Surat (2.3). Disease reactions of the entries significantly differed at Pantnagar. Entries showed moderately resistant reactions to anthracnose. Five top ranked entries were SPV 2371, SPV 2363, SPV 2370, SPV 2369 and SPV 2362 [4.0 to 4.5].

Zonate leaf spot: The disease was recorded only in Pantnagar in moderate form (4.8) (Table 4.4). The entries differed significantly at 5% level on resistance. Three top ranked test entries were SPV 2371, SPV 2373, SPV 2369, SPV 2360 and SPV 2356 [4.0 to 4.5].

Leaf blight: Occurrence of leaf blight was reported from Surat in moderate form (3.4) and from Akola and Coimbatore in traces. Top five low scoring entries were SPV 2365, SPV 2357, SPV 2362, SPV 2360 and SPV 2361 [2.3 to 3.0] (Table 4.5).

Time to flowering: Days to 50% flowering was recorded at Parbhani, Akola, Surat and Dharwad and Coimbatore. Location means varied from 59.7 (Coimbatore) to 79.8 (Akola) days with national mean 68.9 days (Table 4.3). Data was significant at 5% level across locations except Coimbatore. Among the test entries SPV 2372 was the earliest (64.3 days) and SPV 2362 was the latest (71.9 days) to flower.

Plant height: Plant height was recorded at Coimbatore and Dharwad. Mean plant height in these locations was 202.8cm (Coimbatore) and 171.7cm (Dharwad) (Table 4.3). Data was significant at 5% level across locations. Among the test entries SPV 2373 was the shortest (126.7cm) and SPV 2367 was the tallest (232.2cm) in height.

Germination and seed weight: Germination ability of seed was tested in Palem, Coimbatore, Parbhani Akola and Surat centres (Table 4.4). Germination ranged from 39.3% (Palem) to 78.9% (Akola) with national mean 53.8%. Data was significant at 5% level at Palem and Akola. Among the test entries germination was highest in SPV 2369 (62.4%) and lowest in SPV 2373 (48.4%). Seed weight was recorded at Akola, Palem and Coimbatore and entries differed significantly at Akola and Coimbatore. Among the test entries seed weight varies from 2.2 to 3.8g for 100 seed (Table 4.4). SPV 2366 has the boldest seed among the entries (3.8 g/100 seed).

III. Evaluation of forage sorghum experimental varieties/ hybrids/ parental lines for resistance to diseases

Thirty-five forage sorghum entries (excluding checks) consisting of advanced and initial experimental hybrids and varieties in three trials (Initial and Advanced Varietal and Hybrid Trial Multi-cut, Advanced Varietal and Hybrid Trial Single-cut and , Initial Varietal and Hybrid Trial Single-cut) were evaluated for resistance to, downy mildew and foliar diseases in hot spot locations under natural conditions in Coimbatore, Pantnagar, Ludhiana and Surat along with susceptible and resistant checks for different diseases. Foliar diseases destroy active leaf area required for photosynthesis, adversely affect accumulation of sugar in stalk and thus interfere with the quantity and quality of fodder. Most of the foliar diseases of grain sorghum also occur in forage sorghum. Anthracnose, leaf blight, rust, zonate leaf spot and few other leaf diseases occurs almost regularly either in moderate or severe form in various parts of India. They are more seen on forage sorghum as they are purple type than grain sorghum which is mostly tan type. Foliar disease severity index for different locations are given below.

Table S3: Foliar disease severity index for different locations

Trial	Anthracnose				Zonate leaf spot				Grey leaf spot			
	PAN	*LUD*	*SUR*	*COI*	*PAN*	*LUD*	*SUR*	*COI*	*PAN*	*LUD*	*SUR*	*COI*
IAVHT-MC	4.1	1.5	3.7	2.0	4.3	1.0	1.0	1.0	1.0	4.3	1.0	1.0
AVHT-SC	5.3	1.5	3.3	3.4	5.2	1.0	1.0	1.0	1.0	5.4	1.0	1.0
IVHT-SC	4.7	1.5	3.7	1.5	4.7	1.0	1.0	1.0	1.0	4.6	1.0	1.0
Location severity Index (LSI)	**4.8**	**1.5**	**3.4**	**2.3**	**4.7**	**1.0**	**1.0**	**1.0**	**1.0**	**4.8**	**1.0**	**1.0**
Max Score	6.5	2.0	5.0	8.7	6.2	1.0	1.0	1.0	1.0	7.2	1.0	1.0
Total Entry	219	62	204	163	219	62	204	163	219	62	204	163

1. Initial and Advanced Varietal and Hybrid Trial Multi-cut (IAVHT-MC)

Downy mildew: Downy mildew was reported from Coimbatore and Surat with mean incidence 2.4%, 15.1% respectively. Incidence was highly sporadic and CV was high and data were not considered (Table 5.2). Top two entries with respect to less downy mildew were SPH 1809 and SPH 1768 (8.5 to 13.9%).

Sugary disease or ergot: Moderate to high incidence of sugary disease was recorded from Coimbatore but not from any other locations. Showing of the trials in these two locations was very late (27 July), which might have caused pollen starving and the resultant incidence. Data not included because of high CV.

Foliar diseases: AHT entries were evaluated for foliar disease resistance under artificial/natural conditions in hot spots (Pantnagar, Ludhiana, Surat and Coimbatore) locations. The disease severity was scored on a 1-9 rating scale. Anthracnose, zonate and grey lead spot were moderate in incidence. Minor and sporadic incidence of other leaf diseases including leaf blight was noted in one or other locations.

Anthracnose: Anthracnose was recorded in Pantnagar, Surat (Table 1.4) and traces in Coimbatore and Ludhiana. Disease pressure was moderate at Pantnagar (4.1) and low-moderate at Surat (3.7). Disease reactions of the entries significantly differed at Pantnagar location but not at Surat. SPH 1806 was resistant (2.7)

and SPH 1809 (5.5) and Local check (6.0) were susceptible at Pantnagar. All other entries showed moderately resistant reactions here. Top two entries were SPV 2352 and SPH 1806 [2.8 to 3.2].

Zonate leaf spot: The disease was recorded in Pantnagar in moderate form (4.3) (Table 5.1). No other centre reported the disease this year. The entries differed significantly on resistance and SPH 1806 (2.8) was the best performing entry when susceptible check was 6.0. Top two entries were SPH 1806 and SPV 2352 [2.8 to 4.2].

Grey Leaf spot: The disease was recorded in Ludhiana in moderate form (4.3) (Table 5.1). No other centre reported the disease this year on forage. The entries did not differed significantly on. Except SPH 1809 (6.3), all other test entries were moderately resistant. Top two entries were SPH 1808 and SPV 2352 [3.7 to 3.9].

Leaf blight: Occurrence of leaf blight was reported from Surat. Disease incidence was low and entries behaved as resistance. Top two low scoring entries were SPH 1768 and SPV 2352 (3.0) (Table 5.1).

Time to flowering: Days to 50% flowering was recorded at Surat and Coimbatore. Location means were 69.2 (Surat) to 69.8 (Coimbatore) days with national mean 67.3 days (Table 5.1). Data was significant at 5% level at Coimbatore. Among the test entries SPH 1807 was the earliest (65 days) and SPH 1770 was the latest (71.3 days) to flower.

Plant height: Plant height was recorded at Coimbatore. Mean plant height was 245.7cm (Table 5.2). Data was significant at 5% level. Among the test entries SPV 2353 was the shortest (252.7cm) and SPV 2352 was the tallest (291cm) in height.

Germination and seed weight: Germination ability of seed was tested in Coimbatore (Table 5.2). Germination ranged from 46.2% (B58589) to 55.0% (SPV 2352). Data was not significant at 5% level. Top two per cent germination was recorded in SPV 2352 (55.0%) and SPH 1807 (54.3%).

2. Advanced Varietal and Hybrid Trial Single-cut (AVHT-SC)

Downy mildew: Downy mildew was reported from Coimbatore and Surat with mean incidence 12.0%, 11.6% respectively. Incidence was highly sporadic and CV was high and data were not considered (Table 6.2). Top two entries with respect to less downy mildew were CSH 13 and CSV 23F (7.2 to 7.9%).

Sugary disease or ergot: Moderate to high incidence of sugary disease was recorded from Coimbatore but not from any other locations. Showing of the trials in these two locations was very late (27 July), which might have caused pollen starving and the resultant incidence. Data not included because of high CV.

Foliar diseases: AHT entries were evaluated for foliar disease resistance under artificial/natural conditions in hot spots (Pantnagar, Ludhiana, Surat and Coimbatore) locations. The disease severity was scored on a 1-9 rating scale. Anthracnose, zonate and grey lead spot were moderate in incidence. Minor and sporadic incidence of other leaf diseases including leaf blight was noted in one or other locations.

Anthracnose: Anthracnose was recorded in Pantnagar, Surat and Coimbatore (Table 6.1). Disease pressure was moderate at Pantnagar (5.3) and Coimbatore (3.8) and low-moderate at Surat (3.3). Disease reactions of the entries significantly differed at Pantnagar and Coimbatore locations but not at Surat. Coimbatore data not included in mean for high CV. On national average entries were at par and were moderately resistant. Top two entries were SPV 2312 and SPH 1752 [3.4 to 3.9].

Zonate leaf spot: The disease was recorded in Pantnagar in moderate form (5.2) (Table 6.1). No other centre reported the disease this year. The entries differed significantly on resistance and SPV 2312 (4.3) was the best performing entry when susceptible check was 6.0. Top two entries were SPV 2312 and CSV 30F [4.3 to 4.7].

Grey Leaf spot: The disease was recorded in Ludhiana in moderate form (5.2) (Table 6.1). No other centre reported the disease this year on forage. The entries did not differ significantly and CV was high. Top two entries were SPH 1752 and SPV 2317 [2.2 to 4.3].

Leaf blight: Occurrence of leaf blight was reported from Surat. Disease incidence was low-moderate and entries behaved as resistance to moderately resistant. Top two low scoring entries were SPV 2312 and SPV 2315 (2.3 to 2.7) (Table 6.1).

Time to flowering: Days to 50% flowering was recorded at Surat and Coimbatore. Location means were 66.9 (Surat) to 66.3 (Coimbatore) days with national mean 66.6 days (Table 6.1). Data was significant at 5% level at

both the locations. Among the test entries SPV 2317 was the earliest (67.3 days) and SPV 2315 was the latest (71.2 days) to flower.

Plant height: Plant height was recorded at Coimbatore. Mean plant height was 226.1cm (Table 6.2). Data was significant at 5% level. Among the test entries SPH 1794 was the shortest (236.7cm) and SPH 1752 was the tallest (267.7cm) in height.

Germination and seed weight: Not reported by the centres for AVHT-SC.

3. Initial Varietal and Hybrid Trial Single-cut (IVHT-SC)

Downy mildew: Downy mildew was reported from Coimbatore and Surat with mean incidence 8.6%, 11.0% respectively. Incidence was highly sporadic and CV was high and data were not considered (Table 7.2). Top five entries with respect to less downy mildew were SPV 2385, SPV 2379, SPV 2384, SPV 2392 and SPV 2389 (4.2 to 7.2%).

Sugary disease or ergot: Moderate to high incidence of sugary disease was recorded from Coimbatore but not from any other locations. Showing of the trials in these two locations was very late (27 July), which might have caused pollen starving and the resultant incidence. Data not included because of high CV.

Foliar diseases: IVHT entries were evaluated for foliar disease resistance under artificial/natural conditions in hot spots (Pantnagar, Ludhiana, Surat and Coimbatore) locations. The disease severity was scored on a 1-9 rating scale. Anthracnose, zonate and grey lead spot were moderate in incidence. Minor and sporadic incidence of other leaf diseases including leaf blight was noted in one or other locations.

Anthracnose: Anthracnose was reported from Pantnagar, Surat and Coimbatore. Disease pressure was moderate at Pantnagar (4.7) and Surat (3.7) and traces at Coimbatore (Table 7.1). Disease reactions of the entries significantly differed at both the locations. Coimbatore data not included in mean for high CV. On national average entries were at par and were moderately resistant. Top five entries were SPV 2376, SPV 2390, SPV 2378, SPV 2383 and SPV 2377 (3.2 to 3.7).

Zonate leaf spot: The disease was recorded in Pantnagar in moderate form (4.7) (Table 7.1). No other centre reported the disease this year. The entries differed significantly on resistance and SPV 2390 (4.0) was the best performing entry when susceptible check was 6.0. Top five entries were SPV 2378, SPV 2383, SPV 2390, SPH 1823 and SPV 2376 [4.0 to 4.3].

Grey Leaf spot: Moderate incidence of grey leaf spot was recorded in Ludhiana (4.6) (Table 7.1). No other centre reported the disease this year on forage. The entries did not differ significantly and CV was high. Top five entries were SPV 2385, SPV 2386, SPV 2391, SPV 2376 and SPV 2390 [2.9 to 3.5].

Leaf blight: Occurrence of leaf blight was reported from Surat. Disease incidence was low-moderate and entries behaved as resistance to moderately resistant. Top five low scoring entries were SPV 2388, SPV 2389, CSH 13, SPH 1823 and SPV 2375 (3.0 to 3.5) (Table 7.1).

Time to flowering: Days to 50% flowering was recorded at Surat and Coimbatore. Location means were 66.9 (Surat) to 64.7 (Coimbatore) days with national mean 65.8 days (Table 7.1). Data was significant at 5% level at both the locations. Among the test entries SPV 2389 was the earliest (62.2 days) and SPV 2387 was the latest (70.5 days) to flower.

Plant height: Plant height was recorded at Coimbatore. Mean plant height was 235.9cm (Table 7.2). Data was significant at 5% level. Among the test entries SPV 2381 was the shortest (212.0cm) and SPV 2379 was the tallest (306.7cm) in height.

Germination and seed weight: Germination ability of seed was tested in Coimbatore (Table 7.2). Germination ranged from 55.7% (SPH 1822) to 65.3% (Pant Chari 5). Data was not significant at 5% level. Top five germination per cent was recorded in the test entries SPH 1822, SPV 2374, SPV 2387, SPV 2376 and SPV 2385 (55.7 to 58.3%). Seed weight was not reported for IVHT-SC.

IV. Evaluation of sweet sorghum experimental varieties/ hybrids/ parental lines for resistance to diseases

This season only one trial for sweet sorghum (Initial and Advanced Varietal and Hybrid Trial Sweet Sorghum) was allotted. Twenty-three genotypes including 14 test entries, 3 checks and four pathology checks were evaluated at Parbhani, Akola, Surat and Pantnagar against sorghum diseases. Entries were evaluated for resistance to grain mold, downy mildew and foliar diseases in hot spot locations under natural conditions in along with susceptible and resistant checks for different diseases.

1. Initial and Advanced Varietal and Hybrid Trial Sweet Sorghum (IAVHT-SS)

Grain mold: Grain mold was recorded at Parbhani, Akola, and Surat. Location severity index (LSI) for grain mold were 6.1 (Palem), 5.5 (Coimbatore), 3.2 (Akola), 1.4 (Parbhani), and 4.6 (Surat) for PGS and 5.8 (Palem), 3.8 (Coimbatore), 3.5 (Akola), 2.4 (Parbhani), and 4.4 (Surat) for TGS. Parbhani data was not included for low disease pressure and high CV.

Panicle grain mold (PGS): Average data over the locations showed that PGS ranged from 3.2 (Akola) to 5.3 (Surat) (resistance to susceptible reaction) and entries were significant at 5% level. At Akola entries showed resistant to moderately resistant and at Surat moderately resistant to susceptible reactions (Table 8.1). Based on pooled analysis of two location data, except the resistant and susceptible checks, all other entries including varietal and hybrid checks were at par in PGS. Top ranked five entries were SPV 2393, SPH 1755, SPV 2401, SPV 2400 and SPV 2395 (3.2 to 4.2).

Threshed grain mold (TGS): Average data over the locations showed that TGS ranged from 3.6 (Akola) to 5.1 (Surat) (moderately resistance to susceptible reaction) and entries were significant at 5% level (Table 8.1). At Akola entries showed resistant to moderately resistant and at Surat moderately resistant to susceptible reactions. Based on pooled analysis of two location data, SPV 2393 showed resistant reaction and all other entries including varietal and hybrid checks were at par in TGS. Top ranked five entries were SPV 2393, SPH 1755, SPV 2401, SPV 2399 and SPV 2395 (3.0 to 4.2).

Based on results of PGS, TGS studies SPH 1755, SPV 2393, SPV 2395 and SPV 2401 were found promising for grain mold resistance.

Downy mildew: Downy mildew was reported from Surat with mean incidence 10.8% and range 3.8 to 20.9%. Incidence was highly sporadic and data were not considered because of high coefficient of variation (CV) even after data transformation. Top five test entries with respect to fewer incidences were SPV 2397, SPV 2398, SPV 2393, SPV 2318 and SPH 1798 (3.8 to 6.9%).

Sugary disease or ergot: Sugary disease was not reported from any centre where sweet sorghum trials were allotted.

Foliar diseases: IAVHT-SS entries were evaluated for foliar disease resistance under artificial/natural conditions in hot spots (Pantnagar and Surat) locations. The disease severity was scored on a 1-9 rating scale. Anthracnose and zonate leaf spot were moderate in incidence. Minor and sporadic incidence of other leaf diseases including leaf blight, grey leaf spot, rough leaf spot and sooty stripe was noted in one or other locations.

Anthracnose: Anthracnose was recorded in Pantnagar, Surat (Table 8.2). Disease pressure was moderate at Pantnagar (4.9) and Surat (4.1). Disease reactions of the entries significantly differed at Surat but not at Pantnagar. All entries showed moderately resistant reactions on national mean. Five top ranked entries were SPH 1755, SPV 2393, SPH 2400, SPV 2268 and SPV 2395 [3.3 to 4.3].

Zonate leaf spot: The disease was recorded in Pantnagar in moderate form (4.5) and in Parbhani as traces (data not included). No other centre reported the disease this year. There was no significant difference among the entries. Five top ranked entries were SPH 1755, SPV 2397, SPH 2401, SPV 2398 and SPV 2394 [4.2 to 4.3] (Table 8.2).

Leaf blight: Occurrence of leaf blight was reported from Akola and Surat. Disease incidence was moderate in all the above locations and significantly different among the entries. Top five low scoring entries were SPV 2393, SPV 2401, SPV 2268, SPH 1755 and SPH 1798 [2.5 to 3.0] (Table 8.2).

Time to flowering: Days to 50% flowering was recorded at Parbhani, Akola and Surat. Location means varied from 65.9 (Surat) to 87.7 (Akola) days with national mean 75.2 days (Table 8.1). Data was significant at 5% level across locations. Among the test entries SPH 1824 was the earliest (66.2 days) and SPV 2268 was the latest (80.4 days) to flower.

Plant height: Plant height for IAVHT-SS trial was not reported by the centres.

Germination and seed weight: Germination ability of seed was tested in Parbhani, Akola and Surat centres (Table 8.1). Surat data was not considered for high CV. Germination ranged from 66.5% (Surat) to 77.1% (Akola) with national mean 71.8%. Data was significant at 5% level at Akola. Among the test entries germination was highest in SPV 2399 (76.8%) and lowest in SPV 2396 (61.2%). Test weight of grain was recorded at Akola and entries differed significantly at 1% level. Seed weight varied from 1.9 to 2.9g/100 seed among the test entries and 2.0 to 2.4 among the hybrid/varietal checks (Table 8.1). No entry recorded seed weight ≥3.0.

V. National grain mold nursery-III

Objective of this study was to monitor stability of grain mold resistance in newly identified and known sources and study pathogen population across locations. Eleven entries promoted last season and contributed by various centres along with two released hybrid and two varieties and four grain mold resistant and susceptible checks were evaluated at grain mold hot spots like Parbhani, Akola, Surat and Hyderabad for third season. Field experiment was conducted in RBD with 3 replications. Each test entry was sown in two rows of 4 m long and 45 cm apart. Grain mold was scored following 1 to 9 rating scale on grains on panicle and on threshed grains. Other grain mold related characters like days to flowering, plant height, panicle compactness, glum cover, fungal load etc were recorded. Results are presented in Tables 10.1 & 10.2. Entries R10-MP 13, GMR156-1, GMR83-1, AKMGR101, SU 1363 and PSVGS106 were resistant for PGS and TGS. Entries AKMGR 104, R 10-MP 13, GMR156-1, PSVGS106, SU 1363 and GMR124-1 recorded less than 20% *Fusarium* and *Curvularia* infection. Top ten promising test entries for different grain mold characters are given below;

Table S4. Promising entries in NGN-III

PGS ≤3.3	TGS <≤3.5	Fusarium	Curvularia	Frequency	Top entries
KMGR101	GMR83-1	GMR83-1	AKMGR104	AKMGR101(3)	R10-MP 13
R10-MP 13	KMGR101	SU1363	PVK801	AKMGR104(2)	SU1363
SVGS106	SU1363	GMR124-1	PSVGS106	GMR124-1(2)	AKMGR101
PVK801	R10-MP 13	R10-MP 13	AKMGR101	GMR156-1(3)	GMR156-1
GMR83-1	GMR156-1	GMR166-1	SU1363	GMR166-1(2)	GMR83-1
SU1363	GMR124-1		R10-MP 13	GMR83-1(3)	PSVGS106
GMR156-1	SVGS106		GMR156-1	GMR84-2(2)	
KMGR104			GMR84-2	PSVGS106(3)	
GMR166-1				PVK801(2)	
GMR84-2				R10-MP 13(4)	
				SU1363(4)	

For study of pathogen population on immature sorghum grains, spikelet containing tender grains were sampled from Parbhani, Akola and Hyderabad at 10 days after 50% anthesis from twelve genotypes including grain mold resistant (B58586) and susceptible (Bulk Y & 296B) checks. From each entry at least 4 to 5 panicles were sampled, pooled and immediately sent to IIMR Hyderabad for fungal study. Means of fungal infections over three locations are presented in Table S5. Seven different fungal genera were detected including *Fusarium, Curvularia, Alternaria, Aspergillus, Bipolaris, Penicillium* and *Rhizopus*. *Fusarium* and *Curvularia* were major in frequency while others were low. Among entries the infection ranged from 13.8 (GMR 156-1) to 52.9 (CSH16) for *Fusarium*; 5.9 (GMR 156-1) to 24.4% (AKMGR 104) for *Curvularia*; 0.0 (AKMGR 101) to 12.5 (CSH23) for *Alternaria;* 0.0 (AKMGR 101) to 4.0 (B58586) for *Bipolaris;* and 0.2 (CSV 20) to 7.7 (GMR 166-1) for *Aspergillus.* However, the differences among the entries were not significant as CV was high due to airborne nature of infection.

Table S5. Frequency (%) of airborne fungal infection on immature seed of different entries

Sr.	Entry	*Fusarium*	*Curvularia*	*Alternaria*	*Bipolaris*	*Aspergillus*	Total infection
1	AKMGR 101	40.0	7.8	0.0	0.0	0.5	50.1
2	AKMGR 104	32.8	24.0	9.2	2.3	2.6	71.5
3	GMR124-1	48.6	15.8	10.3	1.3	5.8	75.3
4	GMR156-1	13.8	5.9	5.5	0.8	4.8	31.0

Sr.	Entry	*Fusarium*	*Curvularia*	*Alternaria*	*Bipolaris*	*Aspergillus*	Total infection
5	GMR166-1	35.0	16.9	2.3	1.5	7.7	68.0
6	GMR83-1	29.0	16.5	3.7	1.2	2.0	51.6
7	CSH16	52.9	17.1	2.8	0.3	5.0	79.3
8	CSH23	36.1	5.9	12.5	1.6	0.2	70.0
9	CSV20	26.3	14.0	8.3	2.8	0.2	46.2
10	B58586	36.2	18.8	5.8	4.0	5.3	68.9
11	Bulk Y	26.0	23.8	3.7	0.5	3.2	57.7
12	296B	24.2	22.3	2.2	3.0	2.7	53.9
	Mean	**33.4**	**15.7**	**5.5**	**1.6**	**4.2**	**61.1**
	C.V. (%)	49	53	84	74	153	28
	F (Prob.)	0.30	0.12	0.32	0.13	0.31	0.17

VI. National grain mold nursery-I&II

Twenty-one entries contributed by various centres were evaluated along with grain mold resistant and susceptible checks at grain mold hot spots like Parbhani, Akola, Surat and Hyderabad. Field experiment was conducted in RBD with 3 replications. Each test entry was sown in two rows of 4 m long and 45 cm apart. Grain mold was scored following 1 to 9 rating scale on grains on panicle and on threshed grains. Other grain mold related characters like days to flowering, 100 seed weight and fungal load etc were recorded. Results are presented in Tables 9.1 & 9.2. Entries GMN14-6 was resistant and AKGMR111, GMN14-3, GMN14-9, GMN15-1, IS20956, IS21425, IS21645, IS23590, IS29314 and RMP42 were moderately resistant and highly promising for grain mold resistance. They will be further evaluated in multiple locations for confirmation of resistance and stability.

VII. Anthracnose resistant nursery

Earlier studies on characterization of the virulence spectrum of the anthracnose pathogen in hot spot locations revealed high degree of variability among the isolates in Pantnagar and Udaipur regions where forage sorghum is important. Study revealed that susceptibility of few sorghum lines had changed over the years. CSV21F and IRTA204 lines which were resistant or moderately resistant to CgA, CgB, CgD and CgL isolates during 2012, showing susceptible reactions during 2014. It was decided to identify new sources of anthracnose resistant that could be used for a resistant breeding programme.

Fifteen sorghum lines were tested for anthracnose resistance at hot spot (Pantnagar) along with three checks. Disease pressure was moderate to high where the susceptible check, Kekri Local scored 6.5. Five lines IS 2095, ICSB 12021, IS 10302, IS 23521 and IS 473 were at par in resistance (4.8 to 5.0) with Pant Chari 5 (4.0).

Table S6. Anthracnose variability nursery

S. No.	Entry	Anthracnose (1-9)	S. No.	Entry	Anthracnose (1-9)	S. No.	Entry	Anthracnose (1-9)
1	ICSB 405	6.2	8	ICSB 474	5.2	15	IS 473	5.0
2	CSV 21 F	5.5	9	ICSB 654	5.7	16	Kekri Local	6.5
3	ICSB 12012	5.7	10	IS 10302	5.0	17	Pant Chari 5	4.0
4	ICSB 12015	6.2	11	IS 2095	4.8	18	SSG 59-3	6.5
5	ICSB 12019	5.3	12	IS 23521	5.0		Mean	5.5
6	ICSB 12021	4.8	13	IS 23586	5.5		CD at 5%	1.0
7	ICSB 467	5.8	14	IS 3089	6.5		CV %	5.9

VIII. Screening technique development

Four methods of inoculation were assessed on four genotypes of sorghum for artificial development of pokkah boeng under field conditions so that sources of resistance against this disease can be identified. Presently source for resistance to this disease is not known and artificial screening technique is not available. Inoculation methods were foliar spray of spore suspension (FS), stem injection of spore suspension with hypodermic needle (SI), application of pathogen colonized sorghum grains into the whorl (WA), and untreated control (NI). Disease incidence and severity of pokkah boeng was recorded at both vegetative (45DAS) and reproductive (75 DAS) crop stages. Both disease incidence (DI) and disease severity index (DSI) increased from vegetative to reproductive stage. Stem injection produced highest disease incidence (43.5%) and severity index (26.4%) followed by whorl application (incidence 31.3%; severity index 18.2%) (Fig.2a) and stem injection was more stable than whorl application across years. Studies on interrelationship among traits by conventional correlation analysis and biplot analysis revealed that grain yield, plant height and earhead length were affected by the

disease (Fig. 2b). Stem injection developed high amount of disease and caused grain yield loss of 25.8%. This is the first instance where a suitable artificial inoculation method has been identified for screening sorghum genotypes for pokkah boeng resistance.

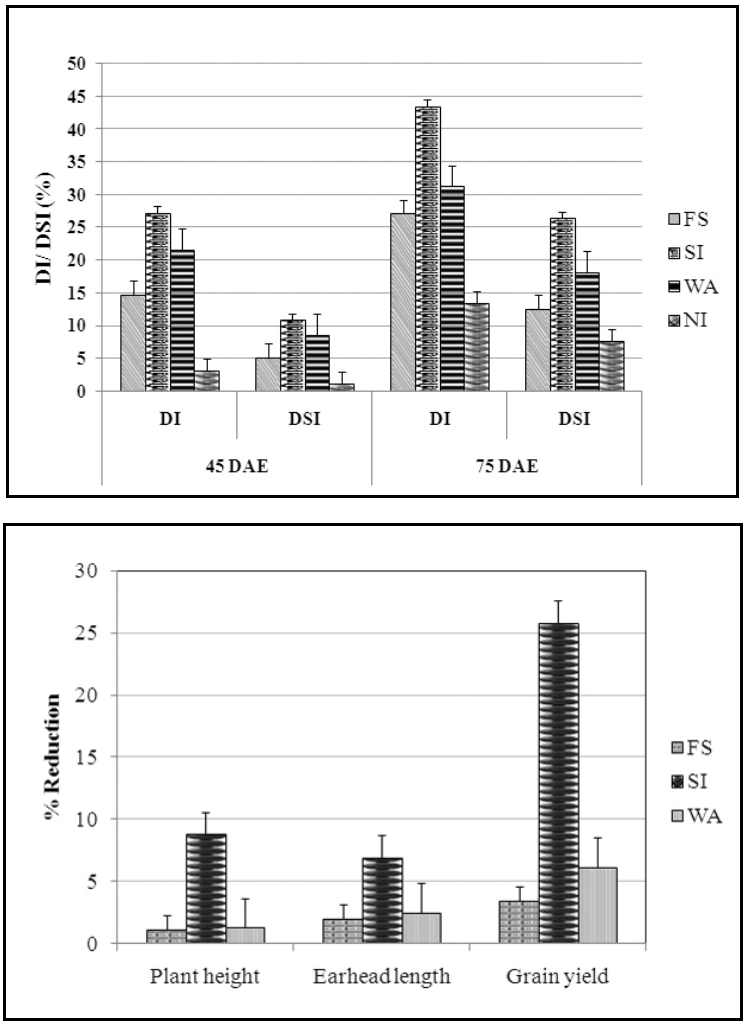

Fig. 2. Effects of artificial inoculation methods on (a) development of pokkah boeng disease in sorghum (FS= Foliar spray, SI= Stem injection, WA= Whorl application, and NI= Natural control), and (b) grain yield, plant height and earhead length over control.

IX. Pest and disease resistant nursery

Objective of this study was to identify combined resistance for grain mold and shoot fly in newly identified and known sources of resistance. Four locations (Dharwad, Akola, Surat and Pantnagar) for evaluation for diseases resistance and four (Udaipur, Akola, Dharwad, Hyderabad) for pest resistance were chosen. Experiments were conducted for third season using 15 entries that included 7 test entries and 8 checks for pests and disease resistance. The test entries were scored for grain mold and other diseases by pathologist and for shoot fly by entomologist using standard procedures. Pathological results are presented in Table 11.1 & 11.2. Out of these entries three were resistant to grain mold (GMR 156, GMR 308, GMR 309 and NRCS-FR-09-3 were at par with resistant check B58586 (2.2 to 4.0 on 1-9 scale) and others were moderately resistant. Seed weight of the above mold resistant entries varied from 2.2 to 2.9 g/100 seed. Seed size of GMR 308 (2.9) was significantly more that of the grain mold resistant check B58586 (1.9). All the entries were moderately resistant to anthracnose and zonate leaf spot.

X. Publications and recognitions

The group was involved in publishing 16 articles including eight journal papers and eoght other publications during 2015-16. Scientists from different centres participated in national and international symposia. Dr IK Das, principal scientist and PI AICRP-Sorghum Pathology was awarded 'Fellow of Indian Phytopathological Society' at the 6th International Conference on 'Plant, Pathogens and Peoples, held on Feb. 23-27, 2016 at NASC Complex, New Delhi. List of publications by the sorghum group is given below.

(A) Journal Article

1. Bhanderi G, Prashant B, Sandipan, Patel NV and Davda BK. (2015). Impact of various fungicides against the ergot disease of sorghum caused by *Claviceps* sp. under South Gujarat condition of Gujarat. **Journal of Plant Development Sciences**, 7 (10): 773-776.
2. Das IK, Rakshit S, and Patil JV (2015). Assessment of artificial inoculation methods for development of sorghum pokkah boeng caused by *Fusarium subglutinans*. **Crop Protection** 77: 94-101.
3. Kharayat, BS and Singh Y. (2015). Characterization of *Erwinia chrysanthemi* isolates inciting stalk rot disease of sorghum. **African Journal of Agricultural Research** 10 (22): 2309-2314.
4. Rekha and Singh Y. (2015). Effect of different planting dates on anthracnose of sorghum. **The Bioscan**.10 (1): 469-472.
5. Rukaiyya Khan, Ameer Basha, Goverdhanam Ragavendra, Poorna Chandra Rao, Yuhei Tanemura, Yoshinori Fujimoto, Ahil Sajeli Begum (2016). Attenuation of TNF-α secretion by L-proline-based cyclic dipeptides produced by culture broth of Pseudomonas aeruginosa. **Bio-organic and Medicinal Chemistry Letters**, 2015, doi:10.1016/j.bmcl.2015.10.075.
6. Singh V and Singh Y. (2015). Bioefficacy of Botanicals against *Exserohilum turcicum* causing Leaf Blight of Sorghum. **Vegetos** 28(2):148-152.
7. Singh V. and Singh Y. (2015). Evaluation of fungicides against sorghum leaf blight pathogen *Exserohilum turcicum.* **Indian Journal of Plant Protection**. 43 (3):360-363.
8. Verma G and Singh Y. (2015). Evaluation of biocontrol agents and mycorrhizae against *Gloeocercospora sorghi* causing zonate leaf spot of sorghum (*Sorghum bicolor*) with respect to disease reduction and growth parameters. **Indian Phytopathology** 68 (2): 156-160.

(B) Book Chapter

1. Das IK. (2015). Millet diseases: Current status and future research need. In: Tonapi VA and Patil JV, (Eds.), Millets: Ensuring climate resilience and nutritional security. Daya Publishing House, New Delhi-110035, pp.445-471.
2. Das IK, (2016). Diseases of sorghum. In: Dube, SC, Aggarwal R, Patra TSSK, and Sharma Pratibha, (Eds.), Diseases of Fruit Crops and their Management. Today & Tomorrow's Printers & Publisher, New Delhi. pp. 131-179.

(C) Popular article/ Conference paper/Report

3. Das IK and Sharma S. (2015). Jowar me grain mold hetu ekikrit prabandhan. Jowar Sourav, 5(2014): 22-23 (Hindi).
4. Das IK, Govardhan C, and Nageshwar Rao TG. (2016). Pokkah boeng of sorghum: possibility of management through varietal resistance. Paper presented in the 6th International Conference on 'Plant, Pathogens and Peoples, held on Feb. 23-27, 2016 at NASC Complex, New Delhi. P(S20)672.
5. Kalpande, H.V. Waskar, D.W. Mohd.Ilyas, More A.W., Gholve, V.M. Aundhekar, R.L. Dhutmal R. and Ambilwade P. (2015). Jowar Lagvad Tandranyan v Vavthapan (a book in Marathi). Vasantrao Naik Marathwada Agricultural University, Parbhani, Maharashtra.
6. Kalpande, H.V. Gholve, V.M. Mohd. Ilyas, More, A.W. Solanke, S.S. Aundhekar, R.L. Ambilwade P. and Chavan S. (2015). Jowarivaril Rog v tyache Vavthapan (in Marathi). Vasantrao Naik Marathwada Agricultural University, Parbhani, Maharashtra.
7. Kavino, M. Manoranjitham, S.K. Kumar N. and Vijayakumar R. M. (2015). Plant growth stimulation and bio control of fusarium wilt (*Fusarium oxysporum* f. sp. *cubense*) by co-inoculation of banana (*Musa* spp.) plantlets with PGPR and endophytes OP-12 in 4th Asian PGPR congress held at Vietnam on 3-6th May, 2015.
8. Sharma, D. and Singh Y. 2016. Major diseases of sorghum in Tarai region of Uttarakhand and their management. Indian Farmers' Digest 49 (2): 16-17.

Annexure I: Performance of the Centres

Trial No.		1	2	3	4	5	6	7	9	10	11	12	13
Sr.	Trail/ Location	AHT-GS	AVT-GS	IHT-GS	IVT-GS	IAVHT-MC	AVHT-SC	IVHT-SC	IAVHT-SS	NGN-I&II	NGN-III	PDRN	AVN
1	Parbhani	Y	Y	Y	Y	–	–	–	Y	Y	Y	Y	–
2	Akola	Y	Y	Y	Y	–	–	–	Y	Y	Y	Y	–
3	Dharwad	Y	Y	Y	Y	–	–	–	–	–	–	–	–
4	Coimbatore	Y	Y	Y	Y	Y	Y	Y	–	–	–	–	–
5	Palem	Y	Y	Y	Y	–	–	–	–	–	–	–	–
6	Surat	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	–
7	Pantnagar	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
8	Ludhiana	–	–	–	–	Y	Y	Y	–	–	–	–	–
9	Hyderabad	–	–	–	–	–	–	–	–	Y	Y	–	–

Y= data received in time; '-'= Trial not allotted

Annexure II: Details of collaborator

Centre	Collaborator, Address
Akola	Prof. HS Gahukar, Sorghum Pathologist, Sorghum Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola- 444104, Maharashtra
Coimbatore	Dr. S.K. Manoranjitham Plant Pathologist, Tamil Nadu Agricultural University,Coimbatore-641003, Tamil Nadu
Dharwad	Dr. YD Narayana, Sorghum Pathologist, Main Sorghum Research Station, University of Agricultural Sciences, Dharwad-580005, Karnataka
Ludhiana	Dr. Upasana Rani, Plant pathologist, Pulses section, PBG, Punjab Agriculture University Ludhiana, Punjab
Palem	Dr. Ameer Basha, Asst. Research Officer, Plant Pathology, ANGRAU Regional Agricultural Research Station, Palem-509125, Andhra Pradesh
Pantnagar	Dr. Yogendra Singh, Senior Research Officer, CAS in Plant Pathology, College of Agricultural GB Pant University of Agriculture &Technology, Pantnagar-263145, Uttarakhand
Parbhani	Dr. VM Gholve, Pathologist, AICSIP, Marathawada Agriculture University, Parbhani-413722, Maharashtra.
Surat	Dr NV Patel, Research Scientist, Main Sorghum Research Station, Gujarat Agricultural University, Surat-397007, Gujarat

Annexure III: Disease resistant and susceptible checks

Checks	Grain Mold	SDM	Rust	Anthracnose	Zonate LS	Leaf blight
IS 14332	R	R	R	R	MR	R
B58586	R		R	R	MR	R
Bulk Y	S		S		S	
296B	S	R	R	R	MR	R
QL 3		R	S		S	
DMS 652		S	S		S	
H 112	S	S	S	S	MR	S
IS 2312			R	MR	S	R
Kekri Local	R	S	S	S	S	S
Rampur Local	R			S	S	
Pant Chari				R	R	
SSG 59-3			R	MR	S	MR

R= resistance, S= susceptible, MR= moderately resistance

Appendix 1.1: Diseases and causal organisms

Grade	Disease	Causal organism
1	Grain mold	*Fusarium moniliforme,* J. Sheld*; Curvularia lunata, Phoma sorghina &* other
2	Downy mildew	*Peronosclerospora sorghi* (W. Weston & Uppal) C. G. Shaw
3	Ergot/Sugar diseases	*Sphacelia sorghi* Mc Rae
4	Charcoal rot	*Macrophomina phaseolina* Tassi. Goid
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 & Edgertom ex Deighton
9	Rough leaf spot	*Aschochyta sorghi* Sacc
10	Gray leaf spot	*Cercosspora sorghi Ellis & Everh*
11	Sooty stripe	*Ramulispora sorghi (Ellis & Everh)* Olive & Lefebvre in Olive et.al.
12	Target leaf spot	*Bipolaris sorghi (Sacc)* Shoemaker.

Appendix 1.2: Grades for estimation of diseases

Gran mold*: Field grade/Panicle grain mold rating (PGS), Threshed grade/threshed grain mold rating (TGS)*

Severity Grade	Description (% grains molded on panicle)	Disease Reaction
1	0 to <1	Highly Resistant
2	1-5	Resistant
3	6-10	Resistant
4	11-20	Moderately resistant
5	21-30	Moderately resistant
6	31-40	Susceptible
7	41-50	Susceptible
8	51-75	Highly Susceptible
9	>75	Highly Susceptible

Ergot (incidence)

Grade	Description (% panicle ifected)	Disease Reaction
1	0 to <1	Highly Resistant
2	1-5	Resistant
3	6-10	Resistant
4	11-20	Moderately resistant
5	21-30	Moderately resistant
6	31-40	Susceptible
7	41-50	Susceptible
8	51-75	Highly Susceptible
9	>75	Highly Susceptible

Downy mildew: Calculate in per cent term for systemically infected plants. Grade disease reactions as follows; Resistant =≤5%; Moderately Resistant =6-10% Susceptible =11-30%; Highly Susceptible =≥30%.

Foliar Diseases: (anthracnose, zonate leaf spot, leaf blight, rust, sooty stripe, grey leaf spot, target leaf spot)

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