

Sorghum Entomology - Rabi 2016-17

Evaluation of sorghum experimental varieties and hybrids for resistance to key pests- Rabi (post-rainy) season, 2016-17

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EXECUTIVE SUMMARY

Introduction: In AICRIP on Sorghum Entomology program, a total 116 genotypes under six trials (IAHT-DS, IAVT-DS, IAVHT-SS, AICSIP- SPN, Advanced shoot fly nursery (ASFN), Aphid and shoot bug nursery (APSHN) were evaluated mainly for shoot fly, stem borer, sugarcane aphids and shoot bugs for resistance/tolerance at respective hot spot locations (Kovilpatti, Dharwad, Bijapur, Rahuri, Parbhani, Solapur and Hyderabad). For shoot fly evaluation the entries were evaluated under artificial condition by placing fish meal for shoot fly attractions. Whereas, the lines for stem borer, aphids and other pest were evaluated under natural conditions.

Pest scenario in sorghum: In Rabi sorghum, shoot fly (*Atherigona soccata* Rond.) is a major biotic constraint followed by stem borer (*Chilo partellus* Swin.), sugarcane aphid (*Melanaphis sacchari* Zehntner), and shoot bug (*Peregrinus maidis* Ashm.). In Kovilpatti region, the survey was carried out in 27 farmer's field at seven locations. There was severe monsoon failure leading to crop failure at certain locations. The extent of damage by shoot fly ranged from 7 - 10% with mean damage of 17.5 % deadhearts. The damage by stem borer was to the tune of 9.7 %. In Dharwad region, 20 fields were surveyed covering Dharwad, Belgavi, Gadag, Bagalkot, Belagavi districts. The incidence of shoot fly ranged from 28 - 65 % with mean of 43.9 % deadhearts. The incidence of stem borer was negligible (< 1%). The populations of other pest were negligible during the cropping season. At Bijapur the shoot fly incidence was moderate to severe (10 - 35%) with an average of 22.2%. The stem borer infestation was up to 4.8%. Shoot bug damage was low (16.5%). Aphid damage was recorded up to 10 %. The sorghum midge population was negligible. The head bug incidence was up to 7.3%. In western Maharashtra, in Ahamednagar district, the incidence of shoot fly was high 31- 60% deadhearts with a mean of 42 %. Whereas, the appearance of sugarcane aphid was high 2 damage rating (20%) at 70 DAE. The shoot bug incidence was low during seedling and later stage (up to 7%). In Marathwada region (Beed, Osmanabad district) the incidence of shoot fly was (3-11 %) with an average of 7.2%. The mean stem borer incidence was 4.9 %. The infestation of shoot bug was low (< 5%) while incidences of aphid were up to 10%.

Shoot fly (*Atherigona soccata*, Rond):

General trend: The mean shoot fly incidence across locations in all the entomology trials ranged from 20.5 -71.2% deadhearts, the overall mean was 33.8 % deadhearts. Location wise shoot fly infestation was lowest at Kovilpatti (18.7%) followed by Hyderabad (20.5 %), Solapur (22.7%), Bijapur (28 % DH), Dharwad (30.9%), Parbhani (44.2%) and highest at Rahuri (71.2 %), when evaluated under artificial conditions.

Initial and Advance Hybrid Trial for deep soil (IAHT-DS): The mean shoot fly infestation in terms of deadhearts ranged was from 19.3 to 77.0% with an average of 42.6 % deadhearts across the locations. The entries SPH 1864 and SPH 1865 were on par with resistant check, IS 18551.

Initial and Advance Varietal Trial for deep soil (IAVT-DS): Across the locations and genotypes the range was from 18.2 - 68.7% deadhearts with an average of 42.6%. The entries M35-1, SPV 2405, SPV 2473, SPV 2475, SPV 2468 and SPV 2472 were promising.

Initial and Advance Hybrid Trial for shallow soil (IAVHT-SS): The mean shoot fly infestation in terms of deadhearts ranged was from 14.8 to 79.7% with an average of 38.9 % deadhearts across the locations. The entries SPH 1835, SPV 2483, SPH 1835, SPV 2414, SPV 2487, SPH 1873 and CSV 26 were on par with resistant check, IS 18551.

Shoot Pest Nursery (SPN): The mean shoot fly infestation in terms of deadhearts ranged was from 24.6 – 73.2 % with a trial average of 34 % deadhearts across the locations. The entries SPV 2330, SPV 2230, SPV 2139, SPV 2225, SPV 2338 and SPV 2345 were on par with resistant check.

Advanced Shoot fly Nursery (ASFN): The mean shoot fly infestation in terms of deadhearts ranged was from 9.6 – 57.7 % with a trial average of 25.2 % deadhearts across the locations. The entries RSV 1885, NRCSEFPR 09-3(3), Local check, RSV 1978, AKSV 155R and RSV 1880 were on par with resistant check.

Spotted stem borer (*Chilo partellus*, Swinhoe)

General trend: The mean borer incidence across locations in all the entomology trials ranged from 7.7 – 19.2% deadhearts, the overall mean was 11.8 % DH. Location wise shoot fly infestation was lowest at Rahuri (7.7% DH) followed Bijapur (7.9% DH), Parbhani (9.2%), Kovilpatti (10.4% DH), Hyderabad (16.6 % DH) and highest Solapur (19.25DH) when evaluated under natural conditions.

Initial and Advance Hybrid Trial for deep soil (IAHT-DS): The mean stem borer infestation in terms of deadhearts ranged was from .6 – 18.6 % DH the trial average was 12.5 %. None of the entries were on par with resistant check however the entries SPH 1834, CSH 15R, SPH 1801, SPH 1869 and SPH 1865 recorded low deadhearts.

Initial and Advance Varietal Trial for deep soil (IAVT-DS): Across the locations and genotypes the range was from 5.9 – 21.6 % DH and the trial average was 11.1 %. None of the entries were on par with resistant check however the entries CSV 29R, SPV 2408, SPV 2479, SPV 2474, SPV 2475, SPV 2477 and CSV 22 recorded low deadhearts.

Initial and Advance Hybrid Trial for shallow soil (IAVHT-SS): The mean stem borer infestation in terms of deadhearts ranged was from 6.9- 19.1 % DH and the trial average was 11.2 %. None of the entries were on par with resistant check however the entries SPV 2414, SPH 1833, SPV 2418, Phule Maulee and SPV 2416 recorded low deadhearts.

Shoot Pest Nursery (SPN): The mean stem borer infestation in terms of deadhearts ranged was from 5.3- 19.4 % DH and the trial average was 11.2 %. None of the entries were on par with resistant check however the entries SPV 2232, SPV 2330, SPV 2217 and SPV 2139 recorded low deadhearts.

Advanced Shoot fly Nursery (ASFN): The mean stem borer infestation in terms of deadhearts ranged was from 8.2 – 17.1 % DH and the trial average was 9.8 %. None of the entries were on par with resistant check however the entries RSV 1687, RSV 1918, RSV 1855 and RSV 1816 recorded low deadhearts.

Sugarcane aphids (*Rhopalosiphum maidis*):

Aphid and shoot bug Nursery (APSHN): The data on plant damage rating (1-9) due to sugarcane aphid was recorded at Bijapur, Hyderabad, Parbhani, Rahuri and Solapur. The damage rating across the locations ranged from 2.3 – 6.7 with a trial average of 5.0. The damage rating location wise are Solapur (6.7), Hyderabad (5.8), Rahuri (5.6), Parbhani (4.5) and Bijapur (2.3). Across the locations and genotypes the entries PBR-110 and Hathi Kunta were the only entries on par with resistant check. The promising entries in other trials are as follows:

Head bug (*Calocoris angustatus*): Head bug damage rating at milk stage was recorded in Kovilpatti. The damage rating ranged from 1.3 – 5.3 on 1 – 9 scale averaging 2.6. The entries SPV 2330, SPV 2221, SPV 2220 recorded low head bug damage score (1.3).

Shoot bug (*Peregrines maidis*, Ashmead):

Aphid and shoot bug Nursery (APSHN):

The data on damage rating plant damage due to shoot bug was recorded at Bijapur. The infestation was moderate. Across the genotypes, the damage score range was from 1.0 – 5.7, the average was 2.6. The entries SLV 142, CSV 216R, SLV 145(2), SLR 72, PBN ENT-2, M 35-1, recorded low shoot bug infestation.

Management of shoot pests in sorghum through eco-friendly approaches: An IPM module was tested during Rabi 2015-16, comprising of following the treatments: T1:Seed treatment with Imidacloprid 48%FS @ 12ml/kg + Intercropping with chickpea: Sorghum (4:2) + NSKE (5%) spray at 45DAE; T2: Seed treatment with Biofertilizers (Trichoderma+ PSB + Azospirillum)+ 50% Neem cake(1q/ha)+50% + Vermicompost (4q/ha) at the time of sowing + NSKE (5%) spray at 45DAE; T3: Seed treatment with Biofertilizers (Trichoderma+ PSB + Azospirillum)+ Btk @ 2g/let at 25 DAE -Spray of *Lecanicillium lecani* @ 2ml/l at 45DAE; T4: Seed treatment with Imidacloprid 48% FS @ 12ml/kg + Eco feast crop like one row of cowpea around sorghum + NSKE (5%) spray at 45DAE; T5: Seed treatment with Imidacloprid 48%FS @ 12ml/kg + Cypermethrin @ 2ml/l spray at 45DAE; T6: Soil application of Carbofuran 3G (25kg/ha) + Seed treatment with Chlorpyrifos 20EC @ 5ml in 20ml of water + Spray of Cypermethrin @ 2.0ml/l at 25 DAE (RPP of UAS, Dharwad) and T7: Farmers practice.

There was no significantly differences among the treatments in reducing damage by shoot fly and stem borer, However for aphids the treatments T1, T2, T5 and T6 were on par and significantly superior over T7 (Farmers practice). The treatments T5, T1 T6 and T4 were effective over other treatments in reducing shoot bug population. There was no significant difference in sorghum grain equivalent yields among the treatments but in terms of gross income realized and net profit there was 32.9 % increase in net profit in T5 (Seed treatment with Imidacloprid 48%FS @ 12ml/kg + Cypermethrin @ 2ml/l spray at 45DAE) over the farmers practice followed by T3 (26.7%). Lowest net profit was realized in T2 (6.8 %) over the farmers practice.

Future work plan Rabi 2017-18:

- New Germplasm accessions may be evaluated at hot spot locations to identify improved sources for major pests.
- **Shoot fly:** Bijapur, Dharwad, Parbhani, Solapur and Rahuri Centre's may be considered as hot-spot for shoot fly screening. Observations on shoot fly should be recorded under artificial infestation (fish meal technique).
- **Stem borer:** Bijapur, Parbhani and Solapur to be considered as hot-spot for testing stem borer resistance.
- **Aphid/shoot bug:** For aphid and shoot bug, Rahuri, Bijapur and Solapur to be considered.
- **Midge:** It is not regular pest but incidences recorded occasionally at Dharwad, and Kovilpatti. These centers may be considered as testing spots for midge.
- **Biopesticides/new molecules:** Evaluating of bio-pesticides and new molecules may be taken up against major pest.
- **Large scale IPM:** Large scale IPM trials through on-farm testing (OFT) to be done at Parbhani.
- **Organic IPM:** Efforts initiated at Bijapur need to be validated at least 2 locations.

DETAILED REPORT

I. Pest survey and surveillance and seasonal abundance (seven locations)

In most of the parts, there were early showers and very long gap resulted deficit during Rabi season. Terminal drought was occurred where very low residual moisture was available. The shoot fly (*Atherigona soccata* Rond.) is a major biotic constraint followed by the stem borer (*Chilo partellus* Swin.). However, in Rabi season, sugarcane aphid (*Melanaphis sacchari* Zehntner), and corn plant hopper (shoot bug) (*Peregrinus maidis* Ashm.) were seen as major pests in some of the regions.

- a. **Tamil Nadu:** The survey was carried out at Surangudi, Doraiswamy puram, Puthukottai, Puthur, Ottapidaram, Kayathar and Kovilpatti, (Tuticorin dt) in 27 farmers field during 1 – 5th standard week. The crop was sown during 10.10.2016 to 24.10.2016 under rainfed condition. There was severe monsoon failure leading to crop failure at certain locations. The commonly grown varieties were K 8, PAC 501 and K4. The extent of damage by shoot fly ranged from 7.0 – 10.0% with mean damage of 17.51 % deadhearts. The damage by stem borer was to the tune of 9.72 % (Fig 1).
- b. **Karnataka:** Total 20 fields were observed covering Dharwad, Belgavi, Gadag, Bagalkot, Belagavi districts. The crop was sown with cultivars like M 35-1 and SPV 2217 during 10.10.2016 to 02.11.2016. Overall, the key pest observed during the survey was shoot fly. The incidence of shoot fly ranged from 28 – 65 % with mean of 43.9 % deadheart. The incidence of stem borer was negligible (< 1%). The populations of other pest were negligible during the cropping season (Fig 1).

In Bijapur center, 27 fields from Vijaypur in Bijapur district were monitored. Mostly, M-35-1 and CSV 29 was grown as a sole crop. Some of the fields were grown with sorghum after chickpea, sun flower. The planting was done during 21.09.2016 to 05.10.2016. The shoot fly incidence was moderate to severe (10 to 35%) with an average of 22.2%, stem borer was up to 4.77%. Shoot bug damage was low (16.5%). Aphid damage was recorded up to 10 %. The sorghum midge population was negligible. The head bug incidence was up to 7.3 %. Natural parasitism particularly, *Coccinellids* were observed up to 25% in some of farmer's field.

- c. **Maharashtra:** In western Maharashtra, twenty locations were surveyed in Ahamednagar district. Phule Vasudha and Phule Revati were grown as a sole crop during September-October. Overall incidence of shoot fly was high 31- 60% DH with a mean of 42.0 % when crop was planted in the first fortnight of September. The appearance of sugarcane aphid was high 2 damage rating (20%) at 70DAE. The shoot bug incidence was low during seedling and later stage (up to 7%). The presence of *Coccinella* was sporadic in four fields (3-5/leaf). In Marathwada region, total 13 locations in Beed Osmanabad district were surveyed for pest incidences in Rabi sorghum. Most of the famers have sown CSV 29R, Maldandi (M-35-1) and Parbhani Moti. The incidence of shoot fly was moderate (3-11 %) with an average of 7.2%. The deadhearts due to stem borer was recorded up to 4.92 %. The infestation of shoot bug was low (< 5%). The incidences of Aphid were recorded up to 10%.

Summary of pest situation in sorghum growing states-Rabi -2016

State	Shoot fly (%)	Stem borer (%)	Aphid (%)	Shoot bug (%)	Head bugs (%)
Tamil Nadu (Kovilpatti)	17.5	9.7	3.5	-	-
Karnataka (Dharwad, Bijapur)	32.5	3.6	10.0	16.5	7.3
Maharashtra (Parbhani, Rahuri)	24.6	7.2	15.7	5.3	-

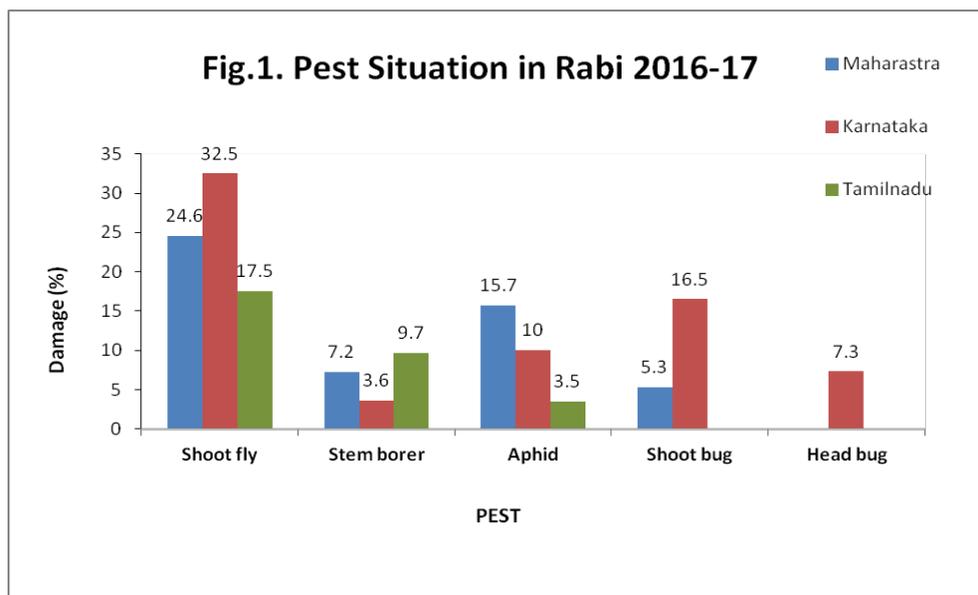


Table 1: Promising entries with less susceptibility to key pests of grain sorghum in different AICSIP trials- Rabi 2016-17 (Locations: 7)

Trial	Shoot fly (<40% DH)	Stem borer (<10% DH)	S. aphids (< 3.0 rating)	Shoot bug (< 2.0 rating)	Head bug (< 2.0 rating)	Midge (< 3.0 rating)
IAHT-DS	SPH 1864, SPH1865	None	<u>SPH 1801</u> , SPH 1867	None	<u>SPH 1869</u> , <u>SPH 1871</u>	<u>SPH 1801</u> , SPH 1867, <u>SPH 1869</u>
IAVT-DS	SPV 2405, SPV 2473, SPV 2475, SPV 2468, SPV 2472	None	SPV 2408, SPV 2471	None	None	SPV 2476
IAVHT-SS	<u>SPH 1835</u> , <u>SPV 2483</u> , SPH 1835, SPV 2414, <u>SPV 2487</u> , <u>SPH 1873</u> .	None	<u>SPV 2483</u>	None	<u>SPV 2414</u> , <u>SPV 2418</u> , <u>SPV 2483</u> , <u>SPV 2487</u>	SPH 1833, SPH 1805, <u>SPH 1873</u>
AICSIP-SPN	<u>SPV 2330</u> , SPV 2230, <u>SPV 2139</u> , SPV 2225, SPV 2338, SPV 2345	SPV 2232, <u>SPV 2330</u> , SPV 2217, <u>SPV 2139</u>	<u>SPV 2330</u>	None	<u>SPV 2330</u> , SPV 2221, SPV 2220	SPV 2281
ASFN	RSV 1885, <u>NRCSEFPR 09-3(3)</u> , RSV 1978, AKSV 155R, RSV 1880	RSV 1687, RSV 1918, RSV 1855, <u>RSV 1816</u>	RSV 1928, RSV 1882, RSV 1855, <u>NRCSEFPR 09-3(3)</u> , RSV 1978	<u>RSV 1928</u> , RSV 1410(2), <u>RSV 1816</u> , RSSGV 3	None	None
APSHN	None	None	PBR-110	SLV 142, SLV 145(2), SLR 72, PBN ENT-2,	None	None

Note: Underlined entries recorded as resistant/tolerant to more than one pest

II. Evaluation of grain sorghum experimental varieties and hybrids for resistance to key pests on different type of soils

Trial 1: Initial and Advance Hybrid Trial for deep soil (IAHT-DS) (Loc: 6)

IAHT-DS comprised of 23 entries having 13 experimental hybrids, two commercial hybrid (CSH 15R, CSH 13), one local check from respective center, four resistant checks (IS 18551, IS 2205, Y 75 and TAM 428) and three susceptible checks (Swarna, SSV 84 and Hathi Kuntha) were evaluated for resistance to key pests at six locations (Bijapur, Dharwad, Kovilpatti, Parbhani Rahuri, and Solapur).

Shoot fly (*Atherigona soccata*, Rond): Deadhearts caused by the shoot fly was recorded at peak stage at Bijapur, Dharwad, Kovilpatti, Parbhani, Rahuri, and Solapur. The data collected all centers was significant at 5% level across the locations and genotypes. The mean ranged was from 19.3 to 77.0% DH with an average of 42.6

% deadhearts across the locations. The mean shoot fly infestation was maximum at Rahuri (77.0 %) followed by Parbhani (55.2%), Dharwad (40.2 %), Bijapur (34.1%), Solapur (29.4%) and minimum at Kovilpatti (19.3% DH). At Bijapur the entries SPH 1801, SPH 1834, SPH 1837, SPH 1863, SPH 1864 and SPH 1865 recorded damage were on par with resistant check, IS 18551. At Dharwad the entries SPH 1801, SPH 1865, SPH 1870, and SPH 1837 recorded damage on par with resistant check. At Kovilpatti the entries SPH 1865, SPH 1863, CSH 15R, SPH 1869, SPH 1871, SPH 1870, SPH 1872, SPH 1866 and SPH 1864 recorded damage on par with resistant check. The entries SPH 1865, SPH 1863, SPH 1864, SPH 1866 and SPH 1868 were on par with resistant check at Parbhani. At Rahuri the entries SPH 1865 and SPH 1864 were on par with resistant check. At Solapur SPH 1837, SPH 1864, SPH 1863, SPH 1834, CSH 15R, SPH 1866, SPH 1868, SPH 1865 and SPH 1867 were on par with resistant check IS 18551. Across the location and genotypes, the SPH 1864 and SPH 1865 were on par with resistant check, IS 18551 at 28 DAE (Table 1.1).

Oviposition preference: The Shoot fly eggs/ 5 plants were recorded at Bijapur, Dharwad, Kovilpatti, Parbhani, Rahuri, and Solapur at 14DAE. The data from all the locations registered high CV %(> 25%) except Parbhani and Rahuri. At Parbhani the oviposition ranged from 2.7 – 8.3 eggs/ 5 plants while at Rahuri the oviposition ranged from 2.3 – 5.0 eggs/5 plants. However, across the locations and genotypes, the Shoot fly eggs/ 5 plants ranged from 1.8 – 4.8 eggs/ 5 plants averaging 3.2 eggs/ 5 plants (Table 1.1).

Spotted stem borer (*Chilo partellus*, Swinhoe): The data on stem borer was recorded at Bijapur, Kovilpatti, Parbhani and Solapur. The data on spotted stem borer infestation was assessed in terms of leaf injury plants (%) at 35 DAE, damage rating (1-9), deadhearts (%) at 45 DAE and stem tunneling (%).

The data on deadhearts at 45 DAE was recorded at Bijapur, Kovilpatti, Parbhani and Solapur. At all the centers the CV % was high (>25.0%). The overall location mean of deadhearts % due to stem borer at 45 DAE was ranged from 8.6 – 18.6 % DH the trial average was 12.5 %. Though insignificant statistically across the locations and genotypes, the SPH 1834, CSH 15R, SPH 1801, SPH 1869 and SPH 1865 recorded low deadhearts. The stem tunneling data was recorded at Kovilpatti and Parbhani had high CV%. The damage ranged from 8.1 – 57.1 % with mean tunneling of 24.9 % (Table1.2).

The data on percent leaf injury was recorded at 35 DAE at Kovilpatti and Solapur. Across the genotypes, locations the data on leaf damage percentage ranged from 1.5 – 4.0, the average being 2.70. Among the test entries SPH1865, SPH 1864, SPH 1801, SPH 1870 and SPH 1868 recorded less than 1.7 leaf injury score (Table 1.2).

Shoot bug (*Peregrinus maidis*, Ashmead): The data on plant damage rating due to shoot bug was recorded at Bijapur. Across the genotypes the score ranged was from 1.0 – 5.0, the average being 1.5. The data was not significant at 5% level (Table 1.2).

Sugarcane aphid (*Melanaphis sacchari*, Zehntner): The data on plant damage rating (1-9) due to sugarcane aphid was recorded at Bijapur, Dharwad, Rahuri and Parbhani. Except for data from Parbhani all others were non-significant. The damage rating across locations ranged from 1.6 – 5.6 with an average of 1.9. Across the locations and genotypes though non-significant the entries CSH 13, SPH 1801 and SPH 1867 recorded low aphid damage rating (Table 1.4).

Midge (*Stenodiplosis sorghicola* Coquille): The data on plant damage rating (1-9) due midge was recorded at Kovilpatti and Bijapur. The damage rating was low and ranged from 1.4 – 2.4, the average being 1.7. The entries SPH 1801, SPH 1834, SPH 1837, SPH 1866, SPH 1867, SPH 1869 and SPH 1870 recorded low damage score (1.0) (Table 1.2).

Head bug (*Calocoris angustatus*): The data on damage rating due to head bug was recorded at Kovilpatti. At Kovilpatti the damage rating ranged from 2.0 – 5.0 with an average of 3.1. There was no significant differences between the test entries, however entries SPH 1869, SPH 1871 low damage rating (2.0) due to head bug (Table 1.1).

Plant stand per plot (1.8 m²): The data on plant population per plot (2 rows of 2 m=1.2 m²) was recorded at Bijapur, Dharwad, Kovilpatti, Parbhani, Rahuri and Solapur. Across the genotypes and locations, the data on plant population ranged from 19.4 – 26.3 plants with an average of 23.3 plants plot⁻¹ (Table 1.3).

Day to (50%) flowering: Days to 50% flowering were recorded at Bijapur, Dharwad, Kovilpatti, Parbhani, Rahuri and Solapur. Overall, shortest duration to flower was recorded in CSH 15R (73.6 days) and the longest flowering was recorded in SPH 1869 (81.2 days) and overall mean days to flower was 77.2 days (Table 1.3).

Grain yield (g)/ 5 plants: Grain yield in grams on five plants was assessed on the basis of 5 plant samples per plot and recorded at Bijapur, Kovilpatti, Parbhani and Solapur. Overall, the range was 236.9 - 657.0 g with a mean of 416.0 g plant⁻⁵. Irrespective of locations and the genotypes, the higher grain yield was obtained in SPH 1872 (657.0 g/ plant⁻⁵) and the lowest was recorded in TAM 428 (236.9 g) (Table 1.4).

Trial 2: Initial and Advance Varietal Trial for deep soil (IAVT-DS) (Loc: 6)

IAVT-DS comprised of 23 entries having 19 experimental varieties, two commercial varieties (CSV 22, CSV 29R), M 35-1, one local check from respective center, four resistant checks (IS 18551, IS 2205, Y 75 and TAM 428) and three susceptible checks (Swarna, SSV 84 and Hathi Kuntha) were evaluated for resistance to key pests at six locations, (Bijapur, Dharwad, Kovilpatti, Parbhani Rahuri, and Solapur).

Shoot fly (*Atherigona soccata*, Rond): Deadhearts caused by the shoot fly was recorded at peak stage at Bijapur, Dharwad, Kovilpatti, Parbhani, Rahuri, and Solapur. The data collected all centers was significant at 5% level across the locations and genotypes. The location mean ranged was from 18.2 to 68.7% DH with a trial average of 42.6 % deadhearts across the locations. The mean shoot fly infestation was maximum at Rahuri (68.7 %) followed by Parbhani (43.4 %), Dharwad (32.3 %), Bijapur (25.4), Solapur (22.3%) and minimum at Kovilpatti (18.2% DH). At Bijapur the entries SPV 2469 and SPV 2477 recorded damage on par with resistant check, IS 18551. At Dharwad the entries M 35-1, SPV 2408, SPV 2476, SPV 2468, CSV 22 and SPV 2477, recorded damage on par with resistant check. The entries SPV 2473, SPV 2471, M 35-1, SPV 2406, SPV 2475, SPV 2472, SPV 2468 and SPV 2407 were on par with resistant check at Parbhani. At Rahuri the entries CSV 22, SPV 2474, SPV 2405, M 35-1, SPV 2473, SPV 2472, 247 and SPV 2479 were on par with resistant check. At Solapur SPV 2406, SPV 2468, SPV 2405, SPV 2472, SPV 2475 and SPV 2473 were on par with resistant check IS 18551. Across the location and genotypes, the entries, M35-1, SPV 2405, SPV 2473, SPV 2475, SPV 2468 and SPV 2472 were on par with resistant check, IS 18551 at 28 DAE (Table 2.1).

Oviposition preference: The Shoot fly eggs/ 5 plants were recorded at Bijapur, Dharwad, Kovilpatti, Parbhani, Rahuri, and Solapur at 14DAE. The data from all the locations registered high CV %(> 25%) except Parbhani and Rahuri. At Parbhani the oviposition ranged from 2.3 – 8.3 eggs/ 5 plants However, across the locations and genotypes, the Shoot fly eggs/ 5 plants ranged from 2.0 – 4.9 eggs/ 5 plants averaging 3.1 eggs/ 5. There was no difference in oviposition preference of the shoot fly plants (Table 1.1).

Spotted stem borer (*Chilo partellus*, Swinhoe): The data on stem borer was recorded at Bijapur, Kovilpatti, Parbhani Rahuri and Solapur. The data on spotted stem borer infestation was assessed in terms of leaf injury plants (%) at 35 DAE, damage rating (1-9), deadhearts (%) at 45 DAE and stem tunneling (%).

The data on deadhearts at 45 DAE was recorded at Bijapur, Kovilpatti, Parbhani and Solapur. At all the centers the CV % was high (>25.0%). The overall location mean of deadhearts % due to stem borer at 45 DAE ranged from 5.9 – 21.6 % DH the trial average was 11.1 %. Though non-significant statistically across the locations and genotypes, the entries CSV 29R, SPV 2408, SPV 2479, SPV 2474, SPV 2475, SPV 2477 and CSV 22 recorded low deadhearts. The stem tunneling data was recorded at Kovilpatti and Parbhani had high CV%. The damage ranged from 6.8 – 80.1 % with mean tunneling of 26.5 % DH (Table 2.2).

The data on percent leaf injury was recorded at 35 DAE at Kovilpatti and Solapur. Across the genotypes, locations the data on leaf damage percentage ranged from 1.8 – 3.2, the average being 2.5. Amongst test entries SPV 2480, SPV 2406, M 35-1, CSV 22, SPV 2476, SPV 2473 and SPV 2472 recorded less than 2.3 leaf injury score (Table 2.2).

Shoot bug (*Peregrinus maidis*, Ashmead): The data on damage rating plant damage due to shoot bug was recorded at Bijapur. Across the genotypes the range was from 1.0 – 3.3, the average being 1.8. The data was not significant at 5% level (Table 2.2).

Sugarcane aphid (*Melanaphis sacchari*, Zehntner): The data on plant damage rating (1-9) due to sugarcane aphid was recorded at Bijapur, Dharwad, Rahuri and Parbhani (Table 2.4). Except for data from Parbhani all were insignificant. The damage rating across locations ranged from 1.8 – 5.5 with a trial mean of 3.0. Across the locations and genotypes though insignificant the entries SPV 2408 and SPV 2471 recorded low aphid damage rating (2.4).

Midge (*Stenodiplosis sorghicola* Coquillet): The data on plant damage rating (1-9) due midge was recorded at Kovilpatti. The damage rating was low and ranged from 1.0 – 9.0, the average being 6.3. The entries SPV 2476 and M 35-1 recorded low damage score (4.0) (Table 2.2).

Plant stand per plot (1.8 m²): The data on plant population per plot (2 rows of 2 m=1.2 m²) was recorded at Bijapur, Dharwad, Kovilpatti, Parbhani, Rahuri and Solapur. Across the genotypes and locations, the data on plant population ranged from 16.7 – 29.3 plants with an average of 23.1 plants plot-1 (Table 2.3).

Day to (50%) flowering: Days to 50% flowering were recorded at Bijapur, Dharwad, Kovilpatti, Parbhani, Rahuri and Solapur. Overall, shortest duration to flower was recorded in Hathi kunta (69.6 days) and the late flowering was recorded in SPV 2412 (82.4 days) and overall mean days to flower was 78.2 days (Table 2.3).

Grain yield (g)/ 5 plants: Grain yield in grams on five plants was assessed on the basis of 5 plant samples per plot and recorded at Bijapur, Kovilpatti, Parbhani and Solapur. Overall, the range was 105.5 – 332.9 g with a mean of 251.5 g plant⁻⁵. Irrespective of locations and the genotypes, the higher grain yield was obtained in SPV 2474 (332.9 g/ plant⁵) and the lowest was recorded in TAM 428 (105.5 g) (Table 2.3).

Trial 3: Initial and Advance Hybrid Trial for shallow soil (IAVHT-SS) (Loc: 6)

IAVHT-SS comprised of 35 entries having 8 experimental hybrids, 13 experimental varieties, 1 popular rabi cultivar (M 35-1), two commercial hybrid (CSH 15R, CSH 13), three popular rabi varieties (Phule Maulee, CSV 26 and Phule Anuradha) one local check from respective center, four resistant checks (IS 18551, IS 2205, Y 75 and TAM 428) and three susceptible checks (Swarna, SSV 84 and Hathi Kuntha) were evaluated for resistance to key pests at six locations (Bijapur, Dharwad, Kovilpatti, Parbhani Rahuri, and Solapur).

Shoot fly (*Atherigona soccata*, Rond): Deadhearts caused by the shoot fly was recorded at peak stage at Bijapur, Dharwad, Kovilpatti, Parbhani, Rahuri, and Solapur. The data collected all centers was significant at 5% level across the locations and genotypes except for Dharwad and Kovilpatti where CV exceeded 25%. The location mean ranged was from 14.8 to 79.7% DH with trial men of 38.9 % deadhearts across the locations. The mean shoot fly infestation was maximum at Rahuri (79.7 %) followed by Dharwad (41.5 %), Parbhani (41.3%), Bijapur (32.6%), Solapur (23.9 %) and minimum at Kovilpatti (14.8 % DH). At Bijapur the entries SPH1835, SPV 2483, SPH 1833, CSV 26, SPV 2487, SPH 1874, SPH 1836 and SPV 2490 recorded damage on par with resistant check, IS 18551. The entries Phule Maulee, SPH 1874, SPH 1875, SPH 1873, SPV 2418, SPV 2482, SPV 2483, SPH 1836, SPV 2484 were on par with resistant check at Parbhani. At Rahuri the entries SPV 2482, SPH 1836 and SP 2418 were on par with resistant check. At Solapur the entries CSV 26, Phule Maulee, SPV 2490, SPH 1836, SPV 2487, SPV 2414, SPH 1875 and SPH 1874 were on par with resistant check IS 18551. Across the location and genotypes, the SPH 1835, SPV 2483, SPH 1835, SPV 2414, SPV 2487, SPH 1873 and CSV 26 were on par with resistant check, IS 18551 at 28 DAE (Table 3.1).

Oviposition preference: The Shoot fly eggs/ 5 plants were recorded at Bijapur, Dharwad, Kovilpatti, Parbhani, Rahuri, and Solapur at 14DAE. The data from all the locations registered high CV %(> 25%) except Rahuri. At Rahuri the oviposition ranged from 2.7 – 5.0 eggs/ 5 plants. However, across the locations and genotypes, the Shoot fly eggs/ 5 plants ranged from 1.7 – 4.7 eggs/ 5 plants averaging 2.9 eggs/ 5 plants, the data was non-significant. (Table 3.1).

Spotted stem borer (*Chilo partellus*, Swinhoe): The data on stem borer was recorded at Bijapur, Kovilpatti, Parbhani Rahuri and Solapur. The data on spotted stem borer infestation was assessed in terms of leaf injury plants (%) at 35 DAE, damage rating (1-9), deadhearts (%) at 45 DAE and stem tunneling (%).

The data on deadhearts at 45 DAE was recorded at Bijapur, Kovilpatti, Parbhani, Rahuri and Solapur. At all the centers the CV % was high (>25.0%). The overall location mean of deadhearts % due to stem borer at 45 DAE was ranged from 6.9 – 19.1 % DH the trial average was 11.2 %. Though insignificant statistically across the locations and genotypes, the SPV 2414, SPH 1833, SPV 2418, Phule Maulee and SPV 2416 recorded low deadhearts. The stem tunneling data was recorded at Kovilpatti and Parbhani had high CV%. The damage ranged from 14.2 – 32.6 % with mean tunneling of 22.8 % (Table 3.2).

The data on percent leaf injury was recorded at 35 DAE at Kovilpatti and Solapur. Across the genotypes, locations the data on leaf damage percentage ranged from 1.5 – 4.0, the average being 2.70. Amongst test entries SPV 2485, SPH 1836, Phule Maulee, SPV 2487, SPV 2484 recorded less than 1.2 leaf injury score (Table. 3.2).

Shoot bug (*Peregrinus maidis*, Ashmead): The data on damage rating plant damage due to shoot bug was recorded at Bijapur. Across the genotypes the range was from 1.0 – 6.3, the average being 2.3. The data was not significant at 5% level (Table 3.2).

Sugarcane aphid (*Melanaphis sacchari*, Zehntner): The data on plant damage rating (1-9) due to sugarcane aphid was recorded at Bijapur, Dharwad, Rahuri and Parbhani. Except for data from Parbhani all were insignificant. The damage rating across locations ranged from 2.2 – 4.4 being an average of 3.0. Across the locations and genotypes though insignificant the entry SPV 2483 recorded low aphid damage rating score (Table 3.4).

Midge (*Stenodiplosis sorghicola* Coquilett): The data on plant damage rating (1-9) due midge was recorded at Kovilpatti and Bijapur. The damage rating was low and ranged from 1.4 – 2.4, the average being 1.7. The entries SPH 1833, SPH 1805, CSH 13 and SPH 1873 recorded low damage score (2.0) (Table 3.2).

Head bug (*Calocoris angustatus*): The data on damage rating due to head bug was recorded at Kovilpatti. At Kovilpatti the damage rating ranged from 2.0 – 5.3 with an average of 2.6. There was no significant differences between the test entries, however entries SPH 1836, SPH 1874, SPV 2348, SPV 2414, SPV 2418, SPV 2482, SPV 2483, SPV 2484, SPV 2487, SPV 2488, SPV 2489, M 35-1, Phule Maulee and CSV 26 recorded low damage rating (2.0) due to head bug (Table 3.1)

Plant stand per plot (1.8 m²): The data on plant population per plot (2 rows of 2 m=1.2 m²) was recorded at Kovilpatti, Parbhani, Rahuri and Solapur. Across the genotypes and locations, the data on plant population ranged from 18.6 – 23.2 plants with an average of 21.5 plants plot-1 (Table 3.3).

Day to (50%) flowering: Days to 50% flowering were recorded at Bijapur, Dharwad, Kovilpatti, Parbhani, Rahuri and Solapur. Overall, earliest to flower was SPV 2490 (73.6days) and the late flowering was recorded in Phule Anuradha (82.5 days) and overall mean days to flower was 78.2 days (Table 3.3).

Grain yield (g)/ 5 plants: Grain yield in grams on five plants was assessed on the basis of 5 plant samples per plot and recorded at Bijapur, Kovilpatti, Parbhani and Solapur. Overall, the range was 142.6 – 544.8 g with a mean of 319.9 g plant⁻⁵. Irrespective of locations and the genotypes, the higher grain yield was obtained in Local check (544.8.0 g/ plant⁵) and the lowest was recorded in Swarna (142.6 g) (Table 3.4).

Trial 4: Shoot Pest Nursery (SPN) (Loc: 5)

Shoot Pest Nursery comprised of 22 entries having 13 experimental varieties (selected over last three years from various AICRIP- Sorghum trials), M 35-1 popular rabi cultivar one local check from respective center, four resistant checks (IS 18551, IS 2205, Y 75 and TAM 428) and three susceptible checks (Swarna, SSV 84 and Hathi Kuntha) were evaluated for resistance to key pests at five locations (Bijapur, Hyderabad, Kovilpatti, Rahuri, and Solapur).

Shoot fly (*Atherigona soccata*, Rond): Deadhearts caused by the shoot fly was recorded at peak stage at Bijapur, Hyderabad, Kovilpatti, Rahuri, and Solapur. The mean deadhearts caused by shoot fly across the locations ranged from 24.6 – 73.2 % with a trial average of 34.0 %. The mean shoot fly infestation (deadhearts) was maximum at Rahuri (73.2 %) followed by Bijapur (30.3 %), Hyderabad (24.6%), Solapur (23.7 %) and minimum at Kovilpatti (22.7%). At Bijapur the entries SPV 2220 and SPV 2232 recorded damage on par with resistant check, IS 18551. At Hyderabad the entries SPV 2225, SPV 2230, SPV 2139, SPV 2338, SPV 2221, SPV 2330, SPV 2281 and SPV 2217 recorded damage on par with resistant check. At Kovilpatti the entries SPV 2345, SPV 2220, SPV 2232, SPV 2330, SPV 2230, SPV 2217, SPV 2281, SPV 2221, SPV 2338, M35-1 and SPV 2139 recorded damage on par with resistant check. The entries SPH 1865, SPH 1863, SPH 1864, SPH 1866 and SPH 1868 were on par with resistant check at Parbhani. At Rahuri the entries SPV 2225, SPV 2230, Local check, SPV 2330, SPV 2139, SPV 2232, SPV 2345, SPV 2338, SPV 2169, SPV 2225 and SPV 2334 were on par with resistant check. At Solapur SPV 2338, SPV 2225, SPV 2330, SPV 2139, SPV 2230, SPV 2232 and SPV 2221 were on par with resistant check IS 18551. Across the location and genotypes, the entries SPV 2330, SPV 2230, SPV 2139, SPV 2225, SPV 2338 and SPV 2345 were on par with resistant check, IS 18551 at 28 DAE (Table 4.1).

Oviposition preference: The Shoot fly eggs/ 5 plants were recorded at Bijapur, Hyderabad, Kovilpatti, Rahuri and Solapur at 14DAE. The data from all the locations registered high CV %(> 25%) except Rahuri. At Rahuri the oviposition ranged from 1.8 – 8.3 eggs/ 5 plants while at Rahuri the oviposition ranged from 2.3 – 5.0 eggs/5 plants. However, across the locations and genotypes, the Shoot fly eggs/ 5 plants ranged from 1.8 – 4.2 eggs/ 5 plants averaging 1.7 eggs/ 5 plants. The entries Local Check, SPV 2221 and SPV 2330 were less preferred (1.8 eggs/5 plants) for oviposition (Table 4.1).

Spotted stem borer (*Chilo partellus*, Swinhoe): The data on stem borer was recorded at Bijapur, Hyderabad, Kovilpatti, Rahuri and Solapur. The data on spotted stem borer infestation was assessed in terms of leaf injury plants (%) at 35 DAE, damage rating (1-9), deadhearts (%) at 45 DAE and stem tunneling (%).

The data on deadhearts at 45 DAE was recorded at Bijapur, Kovilpatti, Hyderabad, Kovilpatti and Solapur. At all the centers the CV % was high (>25.0%). The overall location mean of deadhearts % due to stem borer at 45 DAE ranged from 5.3 – 19.4 %, the trial average was 13.0 %DH. Though insignificant statistically across the locations and genotypes, the entries SPV 2232, SPV 2330, SPV 2217 and SPV 2139 recorded low deadhearts. The stem tunneling data was recorded at Kovilpatti and Parbhani had high CV%. The damage ranged from 6.3 – 57.1 % with mean tunneling of 22.9 % (Table 4.2).

The data on percent leaf injury was recorded at 35 DAE at Hyderabad, Kovilpatti and Solapur. Across the genotypes, locations the data on leaf damage percentage ranged from 2.3 – 6.3, the average being 3.1. There were no significant differences between the entries (Table 4.2).

Shoot bug (*Peregrinus maidis*, Ashmead): The data on damage rating plant damage due to shoot bug was recorded at Bijapur and Solapur. The infestation was low at Bijapur while at Solapur it was moderate. Across the genotypes the damage score range was from 2.3 – 4.2, the average was 3.2. The data was not significant at 5% level (Table 4.4).

Sugarcane aphid (*Melanaphis sacchari*, Zehntner): The data on plant damage rating (1-9) due to sugarcane aphid was recorded at Bijapur and Solapur. The data from Solapur was significant while data from Bijapur had high CV %. The infestation was low at Bijapur while at Solapur it was moderate. The damage rating across locations ranged from 1.6 – 4.7 with an average of 3.2. Across the locations and genotypes the entries Local check and SPV 2330 recorded low aphid damage rating (Table 4.4).

Midge (*Stenodiplosis sorghicola* Coquillet): The data on plant damage rating (1-9) due midge was recorded at Kovilpatti and it was severe. The damage rating ranged from 1.0 – 9.0, the average being 5.4. The Local check and SPV 281 recorded low damage score (2.0) (Table 4.2).

Head bug (*Calocoris angustatus*): The data on damage rating due to head bug was recorded at Kovilpatti. At Kovilpatti the damage rating ranged from 1.3 – 5.3 with an average of 2.6. There was no significant differences between the test entries, however entries SPV 2330, SPV 2221 and SPV 2220 low damage rating (1.3) due to head bug (Table 4.1).

Plant stand per plot (1.8 m²): The data on plant population per plot (2 rows of 2 m=1.2 m²) was recorded at Bijapur, Hyderabad, Kovilpatti, Rahuri and Solapur. Across the genotypes and locations, the data on plant population ranged from 20.7 – 24.8 plants with an average of 22.6 plants plot⁻¹ suggesting sufficient plant stand (Table 4.3).

Day to (50%) flowering: Days to 50% flowering were recorded at Bijapur, Hyderabad, Kovilpatti, Rahuri and Solapur. Overall, shortest duration to flower was recorded in SPV 2345 (77.1 days) and the entry SPV 2225 flowered late (87.4 days) and overall trial mean was 82.4 days (Table 4.3).

Grain yield (g)/ 5 plants: Grain yield in grams on five plants was assessed on the basis of 5 plant samples per plot and recorded at Bijapur, Kovilpatti, Parbhani and Solapur. Overall, the range was 121.9 – 259.5 g with a mean of 181.4 g plant⁻⁵. Irrespective of locations and the genotypes, the higher grain yield was obtained in SPV 2217 (259.5 g/ plant⁵) and the lowest was recorded in TAM 428 (121.9 g) (Table 4.4).

III. Screening of initial and advance material for specific pest resistance

Trial 5: Evaluation of Advanced Shoot fly resistant lines (ASFN) (Loc: 6)

Advanced Shoot fly Nursery (ASFN) comprised of 23 entries having 18 experimental varieties (selected over last three years from various AICRIP- Sorghum trials), M 35-1 popular rabi cultivar one local check from respective center, two resistant checks (IS 18551, IS 2205) and one susceptible checks (Swarna, SSV 84) were evaluated for resistance to key pests at five locations (Bijapur, Dharwad, Hyderabad, Parbhani, Rahuri and Solapur).

Shoot fly (*Atherigona soccata*, Rond): Deadhearts caused by the shoot fly was recorded at peak stage at Bijapur, Dharwad, Hyderabad, Parbhani, Rahuri, and Solapur. The mean deadhearts caused by shoot fly across the locations ranged from 9.6 – 57.7 % with a trial average of 25.2 %. The mean shoot fly infestation (deadhearts) was maximum at Rahuri (57.7 %) followed by Parbhani (36.9 %), Bijapur (17.7%), Hyderabad (16.5 %), Solapur (14.2 %) and minimum at Kovilpatti (9.6 %). At Bijapur the entries Local check, RSSVG 3, RSV 1882, NRCSFPR 09-3(3), RSV 1839, SLV 145(2), RSV 1962, RSV 1880 and RSV 1978 recorded damage on par with resistant check, IS 18551. At Hyderabad the entries RSV 1880, RSV 1410(2), SLV 145(2), RSV 1687 and RSV 1885 recorded damage on par with resistant check. At Parbhani the entries RSV 1882, RSV 1885, RSV 2154, NRCSFPR 09-3(3), Local check recorded damage on par with resistant check. At Rahuri the entries, RSV 1978, NRVSFPR 09-3(3), RSV 104 and Local check, were on par with resistant check. At Solapur entries AKSV 155R, RSV 1918, RSV 1410(2), RSV 1904, RSV 1978 and NRCSFPR09-3(3) were on par with resistant check IS 18551. Across the location and genotypes, the test entries RSV 1885, NRCSFPR 09-3(3), Local check, RSV 1978, AKSV 155R and RSV 1880 were on par with resistant check, IS 18551 at 28 DAE (Table 5.1).

Oviposition preference: The Shoot fly eggs/ 5 plants were recorded at Bijapur, Hyderabad, Parbhani, Rahuri and Solapur at 14DAE. The data from all the locations registered high CV %(> 25%) except Rahuri. At Rahuri the oviposition ranged from 1.8 – 4.3 eggs/ 5 plants. However, across the locations and genotypes, the shoot fly eggs/ 5 plants ranged from 2.1 – 4.4 eggs/ 5 plants averaging 2.4 eggs/ 5 plants. All the entries were statistically on par with resistant check and significantly superior to susceptible check. However the entries Local check, RSSV 1885, RSSV 1978 and RSSGV were less preferred (<2.2 eggs/5 plants) for oviposition (Table 5.1).

Spotted stem borer (*Chilo partellus*, Swinhoe): The data on stem borer was recorded at Bijapur, Hyderabad, Parbhani, Rahuri and Solapur. The data on spotted stem borer infestation was assessed in terms of leaf injury plants (%) at 35 DAE, damage rating (1-9), deadhearts (%) at 45 DAE and stem tunneling (%).

The data on deadhearts at 45 DAE was recorded at Bijapur, Hyderabad, Parbhani, Rahuri and Solapur. At all the centers the CV % was high (>25.0%). The overall location mean of deadhearts % due to stem borer at 45

DAE ranged from 8.2 – 17.1 %, the trial average was 9.8 %DH. Though non -significant, across the locations and genotypes, the entries RSV 1687, RSV 1918, RSV 1855 and RSV 1816 recorded low deadhearts. The stem tunneling data was recorded at Kovilpatti and Parbhani had high CV%. The damage ranged from 7.0 – 10.9 % with mean tunneling of 8.8 % (Table 5.2).

The data on per cent leaf injury was recorded at 35 DAE at Hyderabad and Solapur. Across the genotypes, locations the data on leaf damage percentage ranged from 2.7 – 5.2, the average being 2.7. There were no significant differences between the entries, however the entries RSV 1816, RSV 1978, RSV 1882, RSV 2154 recorded low leaf damage score (3.0) (Table 5.2).

Shoot bug (*Peregrinus maidis*, Ashmead): The data on damage rating plant damage due to shoot bug was recorded at Bijapur and Solapur. The infestation was moderate both at Bijapur and Solapur. Across the genotypes, locations the damage score range was from 3.1 – 3.7, the average was 3.4. The entries RSV 1928, RSV 1410(2), RSV 1816, and RSSGV 3 recorded low shoot bug infestation (Table 5.3).

Sugarcane aphid (*Melanaphis sacchari*, Zehntner): The data on plant damage rating (1-9) due to sugarcane aphid was recorded at Bijapur and Solapur. Except from Hyderabad and Rahuri other centers recorded high CV %. The infestation was low at Bijapur while at Solapur it was moderate. The damage rating across locations ranged from 1.6 – 6.5 with an average of 3.8. Across the locations and genotypes the entries RSV 1928, Local check, RSV 1882, RSV 1855, NRCSFPR 09-3(3) and RSV 1978 recorded low aphid damage rating (Table 5.3).

Plant stand per plot (1.8 m²): The data on plant population per plot (2 rows of 2 m=1.2 m²) was recorded at Bijapur, Dharwad, Parbhani, Rahuri, Solapur and Hyderabad. Across the genotypes and locations, the data on plant population ranged from 26.8 – 22.7 plants with an average of 24.7 plants plot⁻¹ suggesting sufficient plant stand (Table 5.3).

Day to (50%) flowering: Days to 50% flowering were recorded at Bijapur, Dharwad, Parbhani, Rahuri and Solapur. Overall, RSV 1816 was earliest to flower (79.6 days) while RSV 1978 was late flowering (84.4 days). The overall trial mean was 81.5 days (Table 5.3).

Grain yield (g)/ 5 plants: Grain yield in grams on five plants was assessed on the basis of 5 plant samples per plot and recorded at Bijapur, Parbhani Solapur and Hyderabad. Overall, the range was 180.1 – 300.3 g with a mean of 250.7 g plant⁻⁵. Irrespective of locations and the genotypes, the higher grain yield was obtained in RSV 1687 (300.3 g/ plant⁵) and the lowest was recorded in Swarna (180.1 g) (Table 5.3).

Trial 6: Evaluation of initial and advanced material for sugarcane aphids and shoot bug resistance (APSHN) (Loc: 5)

Aphid and Shoot bug Nursery (APSHN) comprised of 25 entries having 17 initial and advanced (mostly from germplasm) lines, land race (M 35-1), (selected over last three years from various AICRIP- Sorghum trials), one local check from respective center, four resistant checks (IS 18551, IS 2205, Y 75 and TAM 428) and three susceptible checks (Swarna, SSV 84 and Hathi Kuntha) were evaluated for resistance to aphids and shoot bug at 5 locations (Bijapur, Parbhani, Rahuri, Solapur and Hyderabad). All entries were evaluated under natural condition and plants were inoculated with aphids (leaf tagging method), where there was poor incidence. The experiment was covered with net to get uniform and maximum aphid population at Solapur. The data were recorded on plant population per plot, aphid damage rating (1-9), days to flowering (50%), plant height (cm) at maturity, and grain yield (g) on 5 plants. The materials were planted with 2 rows of 2 m (45 cm row to row and 12 cm plant to plant).

Sugarcane aphid (*Melanaphis sacchari*, Zehntner): The data on plant damage rating (1-9) due to sugarcane aphid was recorded at Bijapur, Hyderabad, Parbhani, Rahuri and Solapur. The data from Parbhani center recorded high CV %. The damage rating across the locations ranged from 2.3 – 6.7 with a trial average of 5.0. The damage rating location wise are Solapur (6.7), Hyderabad (5.8), Rahuri (5.6), Parbhani (4.5) and Bijapur (2.3). At Bijapur the entries, SLV 181, SLV 169, local check, SLR 72, PBN ENT-2, PBR 110, M 35-1, SLV 182 and SLV 94 were on par with the resistant check (TAM 428). The entries PBR 110, M 35-1, SLV 142 and CSV

2316R were on par with resistant check. At Rahuri none of the entries were comparable to resistant check. At Solapur the entries Local check, IS 2335, PBN ENT-2, SLR 72, PBR-110, SLB 81, CRS 11 and SLV 169 recorded damage on par with resistant check.

Across the locations and genotypes the entries PBR-110 and Hathi Kunta were the only ones on par with resistant check (Table 6.1).

Shoot bug (*Peregrinus maidis*, Ashmead): The data on damage rating plant damage due to shoot bug was recorded at Bijapur. The infestation was moderate. Across the genotypes, the damage score range was from 1.0 – 5.7, the average was 2.6. The entries SLV 142, CSV 216R, SLV 145(2), SLR 72, PBN ENT-2, M 35-1, recorded low shoot bug infestation (Table 6.1).

Plant stand per plot (1.8 m²): The data on plant population per plot (2 rows of 2 m=1.2 m²) was recorded at Bijapur, Dharwad, Parbhani, Rahuri, Solapur and Hyderabad. Across the genotypes and locations, the data on plant population ranged from 18.5 – 25.9 plants with an average of 23.7 plants plot⁻¹ suggesting sufficient plant stand (Table 6.2).

Day to (50%) flowering: Days to 50% flowering were recorded at Bijapur, Hyderabad, Parbhani, Rahuri and Solapur. Overall, SLB 81 was earliest to flower (80.8 days) while PBR-110 was late flowering (93.1 days). The overall trial mean was 86.5 days (Table 6.2).

Plant height (cm): The data on plant height was recorded at Bijapur, Parbhani, Rahuri, Solapur and Hyderabad. Across the genotypes and locations, the data on plant population ranged from 89.2 – 172.6 cm with an average of 148.7 cm (Table 6.1).

Grain yield (g)/ 5 plants: Grain yield in grams on five plants was assessed on the basis of 5 plant samples per plot and recorded at Bijapur, Hyderabad and Solapur. Overall, the range was 123.0 – 237.6 g with a mean of 184.2 g plant⁻⁵. Irrespective of locations and the genotypes, the higher grain yield was obtained in SLV 169 (237.6 g/ plant⁻⁵) and the lowest was recorded in TAM 428 (123.0 g) (Table 6.2).

IV. Management of shoot pests in sorghum through eco-friendly approaches

Trial 7: Evaluation of organic components for shoot pests management in sorghum (Location: Bijapur)

Bijapur: At Bijapur center, an IPM module was tested during Rabi 2015-16, comprising of the following treatments:

- T1: Seed treatment with Imidacloprid 48%FS @ 12ml/kg + Intercropping with chickpea: Sorghum (4:2) + NSKE (5%) spray at 45DAE
- T2: Seed treatment with Biofertilizers (Trichoderma+ PSB + Azospirillum)+ 50% Neem cake(1q/ha)+50% + Vermicompost (4q/ha) at the time of sowing + NSKE (5%) spray at 45DAE
- T3: Seed treatment with Biofertilizers (Trichoderma+ PSB + Azospirillum)+ Btk @ 2g/lit at 25 DAE -Spray of Lecanicillium lecani @ 2ml/l at 45DAE
- T4: Seed treatment with Imidacloprid 48% FS @ 12ml/kg + Eco feast crop like one row of cowpea around sorghum + NSKE (5%) spray at 45DAE
- T5: Seed treatment with Imidacloprid 48%FS @ 12ml/kg + Cypermethrin @ 2ml/l spray at 45DAE
- T6: Soil application of Carbofuran 3G (25kg/ha) + Seed treatment with Chlorpyrifos 20EC @ 5ml in 20ml of water + Spray of Cypermethrin @ 2.0ml/l at 25DAE (RPP of UAS, Dharwad)
- T7: Farmer practice (Untreated)

Shoot fly: In terms of deadhearts at 28 DAE the infestation was low (6.3 -10.4 %), there was no significant differences among the treatments imposed.

Stem borer: In terms of deadhearts at 45 DAE the infestation was low (4.4 -6.8 %), there was no significant differences between the treatments imposed.

Aphids: The aphid infestation ranged from 17.9 – 36.9 nos/5 cm² of leaf indicating moderate levels of infestation averaging 23.9 aphids/ 5 cm² of leaf. The treatments T1, T2, T5 and T6 were on par and significantly superior over T7 (Farmers practice).

Shoot bug: The aphid infestation ranged from 8.1 – 18.7/ plant whorl indicating low levels of infestation averaging 12.8 nymphs, adults/ plant. The treatments T5, T1 T6 and T4 were effective over other treatments in reducing shoot bug population.

Grain yield: The grain yield among the treatments could not be compared since some treatments had intercropping component involved whereas others were sole crop. Hence, Sorghum grain equivalent yields were calculated by converting intercrop yield into sorghum. There was statistically no difference among the treatments.

Nett Profit: Though there was no significant difference in the Sorghum grain equivalent yields but in term of cost of inputs there was difference in the gross income and net profit realized. There was 32.9 % increase in net profit in T5 (Seed treatment with Imidacloprid 48%FS @ 12ml/kg + Cypermethrin @ 2ml/l spray at 45DAE) over the farmers practice followed by T3 (26.7%). Lowest net profit was realized in T2 (6.8 %) over the farmers practice.

Table 7: Evaluations of IPM module for management of shoot pest in sorghum Rabi 2016-17 at RARS, Bijapur

Treatment	SF DH % (28 DAE)	SB DH % (45 DAE)	No. of Aphids/ 5 cm ² leaf	Shoot bugs/ plant (no)	Sorghum grain Yield (Q/ha)	Crop Equivalent yield (q/ha)	Additional cost of cultivation (Rs/ha)	Gross Income (Rs/ha)	Nett Profit (Rs/ha)	Increase over farmers practice (%)
T1	7.7	4.4	21.1	9.3	9.5	21.4	400	53472	44018	19.4
T2	9.6	6.8	17.9	13.3	20.9	20.9	3775	52192	39363	6.8
T3	8.5	5.3	30.9	17.9	22.7	22.7	900	56683	46729	26.7
T4	10.1	5.9	22.6	11.1	20.6	20.6	500	51475	41921	13.7
T5	6.3	5.5	19.0	8.1	20.9	20.9	450	52358	42854	16.2
T6	8.2	5.2	18.6	11.0	24.3	24.3	2700	60750	48996	32.9
T7	10.4	5.7	36.9	18.7	18.4	18.4	0	45925	36871	19.4
Mean	8.7	5.5	23.9	12.8						
C.D (0.05)	NS	NS	8.87	4.54	3.54	NS				
C.V (%)	18.9	20.1	20.7	19.8	10.0	9.3				

Cost of cultivation : Rs. 9054/ ha; Cost of grain : Rs 2500/ quintal

ANNEXURES:- Relevant information on publications, trials conducted, hot spots etc

Annexure 1: List of collaborators from AICSIP centre

No	Name of Collaborator	Brief address	email	Contact no
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Annexure 2: Entomology trials data-Compliance report

S No	Centre	No of trials allotted	Trials sown	Date Sown	Data received in time	Trials vitiated
1	Bijapur	7	7	21.9.16	Y	Nil
2	Dharwad	4	4	22.10.16	Y	Nil
3	Kovilpatti	4	4	25.10.16	Y	Nil
4	Parbhani	5	5	27.9.16	Y	Nil
5	Rahuri	6	6	19.10.16	Y	Nil
6	Solapur	6	6	8.10.16	Y	Nil
7	Hyderabad	3	3	1.11.16	Y	Nil

Annexure 3: Hot spots locations for key pests

Centre (Hot spot)	Key pests
Kovilpatti	Stem borer, midge
Dharwad	Shoot fly, stem borer, midge
Bijapur	Aphids, shoot bug
Parbhani	Shoot fly, Stem borer, shoot bug, Aphid
Rahuri	Shoot fly, aphids, shoot bugs
Tandur	Shoot fly, stem borer
Solapur	Shoot fly, stem borer, aphids, shoot bugs
Hyderabad	Shoot fly, Stem borer, aphids, shoot bugs

Annexure 4: AICSIP Entomology Trials and Nurseries, Rabi 2016-17

Trial No	Name of Trial	Entry	Rep	Plot size	Centers							Total
					Bijapur	Dharwad	Kovilpatti	Parbhani	Rahuri	Solapur	Hyderabad	
1	IAHT- DS	24	3	2 r x 2m	1	1	1	1	1	1	0	6
2	IAVT- DS	30	3	2 r x 2m	1	1	1	1	1	1	0	6
3	IAVHT-SS	35	3	2 r x 2m	1	1	1	1	1	1	0	6
4	AICSIP-SPN	22	3	2 r x 2m	1	0	1	0	1	1	1	5
5	ASFN	23	3	2 r x 2m	1	1	0	1	1	1	1	6
6	APSHN (Aphid & Shoot bug)	25	3	2 r x 2m	1			1	1	1	1	5
7	New IPM module for pest management in Rabi sorghum	7	3	12 r x 5m	1							1
8	Pest survey & surveillance			Farmers field	1	1	1	1	1	1	1	7
	Total	166			8	5	5	6	7	7	4	42

Annexure 5: Parameters for insect pest resistance used for recording observations

SL No	Parameters	Abbreviations
1	Plant population at 12 DAE (No)	PP
2	Shoot fly eggs/5 plants at 14 DAE (No)	SFEG-5PT
3	Shoot fly deadhearts (%) - at peak time	SF-DH%
4	Stem borer leaf injury score (1-9) at 35 DAE	SB-LER
5	Stem borer deadhearts (%) - 45DAE	SB-DH%
6	Stem borer - stem tunneling (%)	SB-ST%
7	Midge - panicle damage rating (1-9)	MG-DR
8	Head bug - panicle damage rating (1-9)	HB-DR
9	Sugarcane aphids-plant damage rating (1-9)	APH-PDR
10	Shoot bug -Plant damage rating (1-9)	SBG-PDR
11	Mite -Plant damage rating (1-9)	MT-PDR
12	Plant height (cm)	PLHT
13	Days to 50% flowering (No)	DFL
14	Grain yield (g)/ 5 plants	GY-5PTS