Sorghum Entomology - Rabi 2013-14

Evaluation of sorghum experimental varieties and hybrids for resistance to key pests- Rabi (post-rainy) season, 2013-14

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EXECUTIVE SUMMARY

Introduction: In collaboration with AICSIP, total 226 genotypes received from ten trials (AVHT-DS, IHT-SS, IVT-DS, IVHT-SS, AICSIP-DS-SPN, AICSIP-SS-SPN, SFR-F$_8$, B & R lines, IASFN and NGSN), one trial on APSHN from DSR (Aphid and shot bug resistance nursery) 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, Tandur, Hyderabad and Solapur. All the entries were evaluated under artificial condition by placing fish

meal for shoot fly attractions. Whereas, the lines for stem borer were evaluated under natural conditions.

Pest scenario in sorghum: In Rabi sorghum, shoot fly (*Atherigona soccata* Rond.) is a major biotic constraint followed by the stem borer (*Chilo partellus* Swin.), sugarcane aphid (*Melanaphis sacchari* Zehntner), and shoot bug (*Peregrinus maidis* Ashm.). They often occur sequentially or together. In most of the parts there were adequate rains during Kharif as a results, *Rabi* crop received good moisture. However, the heavy storm and rains during first week of March caused lodging of standing crops and succumbed to loss in grain yield and fodder quality. In Kovilpatti region, a very low infestation of shoot fly (< 2 %), leaf damage due to stem borer was up to 9 %. The population of ear head caterpillar was up to 0.2 larvae per ear head and the damage rating was 1 to 3. Midge incidence was moderate (0.8%) but low on K-8. Very low population of head bug (7%), shoot bug (4%) and aphid was up to 3%. In Dharwad region, the mean incidence of shoot was 32% dead heart. The populations of aphids was moderate where as stem borer, head bug, shoot bug, ear head caterpillars were negligible during the cropping season. In Bijapur area, some of the fields were grown with sorghum after onion. The shoot fly incidence was moderate to severe (4-51%) with an average of 18%, stem borer was up to 8%. Shoot bug damage was recorded about 4-29% with an average of 21%. Aphid damage was recorded up to 70%. The white grub incidence was recorded up to 9% in this season where sorghum was intercropped with onion. In western Maharashtra, Phule Vasudha and Phule Revati were grown as a sole crop during September-October. Overall incidence of shoot fly was moderate to high (~ 32%). This year no incidence of stem borer was recorded. The infestation rating of sugarcane aphid was recorded up to 7. The shoot bug incidence was low during seedling and later stage. The presence of Coccinella was sporadic in four fields (3-5/leaf). In Marathwada region, most of the famers have sown Dagdi, Maldandi (M-35-1) and Parbhani Moti. The mean incidence of shoot fly was 10.5%. The deadhearts due to stem borer was recorded up to 8%. The infestation of shoot bug was low (< 3%). The incidences of Aphid were recorded up to 3%. In Vidarbha region, The shoot fly incidence was low 8%. The stem borer particularly peduncle damage was recorded up to 11% and aphid damage was up to 15%.

Shoot fly (*Atherigona soccata*, Rond): General trend: The shoot fly incidence recorded moderate to high (33-79%) at Dharwad, Parbhani, Rahuri and Solapur when evaluated under artificial conditions.

Advanced varietal & hybrids trials (DS): In AVHT-DS trial, The range was from 33.0 to 76.7% DH with an average of 50.0 % deadhearts. None of the test entries were on par with resistant check IS 18551.

Initial hybrids and Initial varietal trial (DS & SS): In IHT-SS, the range was from 33.0 to 78.2% deadhearts with an average of 54.6% deadhearts. However, none of the test entries was superior than resistant check IS 18551. In IVT (DS) trial the range was of deadhearts was from 34 to 79 %. None of the test entries was superior to resistant check IS 18551
Germplasm, B & R lines and IASFN: In IASFN, RSV 1003, NRCSFR09-3, RSV 1315, RSE 03, RSV 1410, RSV 1507, RSV 1635, RSV 1698, RSV 1683, RSV 1687, PBN-ENT-2, PBN-ENT-3 and PBN-ENT-4 were promising. In B& R trial promising entries were SLB 72 and SLV 145 and from germplasm trials NSJB 6596, NSJB 6625, CJV 22, POP 39, SEB 11988 are promising.

SFR (F_8) progenies: The promising progenies that recorded low deadhearts EC 19 x EP 133-2-3, EG 15 x EP 57-6-1, CSV 22 x EC 12-4-1, LG Kumbhari local , EC 19, EC 15.

Spotted stem borer (*Chilo partellus*, Swinhoe)
General trend: The stem borer incidence particularly deadhearts % was low (15%). The stem borer damages were recorded at Kovilpatti, Tandur, Rahuri, Bijapur, Parbhani. Stem tunneling was very high in Kovilpatti (up to 70%).

Hybrids and varietal trial (DS & SS): The overall mean of DH % due to stem borer at 45 DAE was 7 %. Whereas the mean peduncle damage and stem tunneling was 40%. In AVHT-DS, The test entry SPH 1742, SPV 2228, SPH 1741, SPH 1744, SPV 2225, CSH 15 R and CSV 29 recorded low deadhearts % at 45 DAE. In IVT & IHT (SS) trial the entries SPH 1767 and SPV 2274 had low deadhearts%.

B & R lines and IASFN: In B & R lines : SLR 72 and SLB 84 recorded low stem borer deadhearts%. In IASN trial the promising entries were RSV 1003, NRCSFR09-3, RSV 1315, RSE 03, RSV 1507, RSV 1607, RSV 1698, RPASV 25 and Surthi

Head bug *(Calocoris angustatus)*: Head bug damage rating at milk stage was recorded in Kovilpatti. The damage range was from 2-5 in the scale of 1-9 averaging 3.5. The entries that showed promises in AICSIP trials are Hathi kuntha, SPH 1721 (2), SPV 2221, SPH 1746, CSV 22, SPV 2282, SPV 2276, CSH 15R, SPV 2281, SPV 2280, SPV 2277, SPH 1764 and SPH 1765

Sugarcane aphids (*Rhophalosiphum maidis*): The data on aphid damage rating (1-9) was recorded at Bijapur, Tandur, Parbhani, Solapur and Rahuri. The range was from 2 to 7 with an average of 4.5 damage rating. In AICSIP trials the entries that recorded low damage are SSV 84, SPV 2221, SPV 2225, SPH 1742, SPV 2281, CSV 22, SPV 2278 and Hathi kuntha. The entries that recorded low aphid damage rating in aphid and shoot bug nursery trial are SLB 64, SLB 77, SLB 79, SLB 80, SLB 83, SLR 31, KR 191 and KR 196.

Shoot bug *(Peregrines maidis*, Ashmead*):* The shoot bug damage rating was observed from 1.0 to 4.0 with an average of 2.5 in the scale of 1-9. The entries, CSH 15R, SPH 1746, SPH 1741, SPH 1767, SPV 2278, SPV 2274, SPV 2277, Hathi kuntha, Local check, CSH 15R, SPV 2290 and SPV 2288 were recorded 3-4 damage rating in AICSIP trial. In aphid and shoot bug nursery trial, SLB 19, CRS 11, Y 75, IS 2205 and B 35 recorded low damage due to shoot bug (<3).

Eco-friendly and organic IPM: In the Integrated pest management trials conducted at two locations: Bijapur and Tandur. Application of Vermicompost (50 %) +Application of de-oiled neem cake or oilneem cake along with (50 %) dose of RDF or application of Vermicompost @ 7.5q/ha+ 50% RDF found better treatment for management of pests and good returns.

Future work plan Rabi 2013-14:

- Extensive Germplasm accessions may be evaluated at hot spot locations to identify improved sources for major pests through collaborative efforts.
- **Shoot fly**: Dharwad, Parbhani, Solapur, and Rahuri centre may be considered as hot-spot for shoot fly screening. Observations on shoot fly should be recorded when deadhearts reaches at 70 % in susceptible check.
- **Stem borer**: Kovilpatti, Bijapur and Parbhani centre to be considered as hot-spot for testing stem borer resistance.
- **Aphid/shoot bug**: For aphid and shoot bug, Rahuri, Bijapur and Solapur may 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 on payment basis for conducting in-door and out-door trials.
- **Large scale IPM**: Large scale IPM trials through on-farm testing (OFT) initiated at Parbhani. Other centers need to follow up.
- **Organic IPM**: Efforts initiated at Bijapur and Tandur need to make more efforts at other locations too.

DETAILED REPORT

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

In most of the parts, there were adequate rains during *Kharif* (20 %), as a results *Rabi* crop was established very well during seedling stage. However, 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 recent years, the infestation of shoot bug at early stage of crop was also reported. The damage by the homopteran pests is greatly amplified by inducing plant moisture stress alone or in association with the prevailing drought conditions. In Bijapur district, since two years white grub incidences was increasing and recorded up to 9%.

a. Tamil Nadu: This year the incidences of major pest were low due to drought condition. At Kovilpatti, two fields from District Thoothukudi at Sinthalakarai and Kumaragiri villages (10 km from the station) were surveyed for pest surveillance study. The crop was sown with locally cultivated sorghum (K8) during second to last week of September 2013. There was low seedling damage due to shoot fly (1.3%) and stem borer damage and leaf damage was up to 9 %. The population of ear head caterpillar was up to 0.2 larvae per ear head and the damage rating was 1 to 3. Midge incidence was moderate (0.8%) but low on K-8. Very low population of head bug (7%), shoot bug (4%) and aphid was up to 3%.
b. Karnataka: In Dharwad region, the key pest observed during the survey was shoot fly. The incidence of shoot fly ranged from 22.00 to 57.14 % with mean of 32% dead heart. The populations of aphids was moderate where as stem borer, head bug, shoot bug, ear head caterpillars were negligible during the cropping season. In Bijapur area, fifteen fields from Ukali, Mangoli, Hegadihal, Komar, and Katnali area were monitored in Bijapur district for pest surveillance. Mostly, M-35-1 was grown as a sole crop. Some of the fields were grown with sorghum after onion. The planting was done during second week of November to third week of December. The shoot fly incidence was moderate to severe (4-51%) with an average of 18%, stem borer was up to 8%. Shoot bug damage was recorded about 4-29% with an average of 21%. Aphid damage was recorded up to 70%. *Coccinellids* were observed in the month of January in some of farmer's field. Since two years the white grub incidence was increasing and recorded up to 9% in this season where sorghum was intercropped with onion.
c. Maharashtra: In western Maharashtra, ten locations were surveyed in Ahemadnagar district. Phule Vasudha and Phule Revati were grown as a sole crop during September-October. Overall incidence of shoot fly was moderate to high (~ 32%) when crop was planted in the first fortnight of September. The late sown crop (November-December) has very meager presence of shoot fly (2%). This year no incidence of stem borer was recorded. The appearance of sugarcane aphid was high 50-60 aphids/leaf and recorded up to 7 damage rating at 70DAE. The shoot bug incidence was low during seedling and later stage. The presence of *Coccinella* was sporadic in four fields (3-5/leaf). In Marathwada region, total 35 locations in Parbhani district were surveyed for pest incidences in Rabi sorghum. Most of the famers have sown Dagdi, Maldandi (M-35-1) and Parbhani Moti. Out of 35 fields, only two were intercropped with chickpea. The incidence of shoot fly was moderate (7-17 %) with an average of 10.5%. The deadhearts due to stem borer was recorded up to 8%. The infestation of shoot bug was low (< 3%). The incidences of Aphid were recorded up to 3%. In Vidarbha region, about twenty farms were surveyed in four districts Washim, Akola, Gadchiroli, and Buldhana districts. The shoot fly incidence was low to moderate (2-13%) averaging about 8%. The stem borer particularly peduncle damage was recorded up to 11%. Aphids damage up to 15% was recorded where sorghum was late grown near wheat farm.

Summary of pest situation in sorghum growing states-Rabi -2013

State	Shoot fly (%)	Stem borer (%)	Aphid (%)	Shoot bug (%)	Head bugs (%)	Remarks
Tamil Nadu	1.3	9.0	3.0	4.0	7.0	Midge was up to 0.8%
Karnataka	32	8.0	60	21.0	2.5	White grubs incidences up to 9% was recorded in Bijapur district
Maharashtra	31.0	8	30	13.0	5.3	*Peduncle damage up to 11% in Parbhani district*

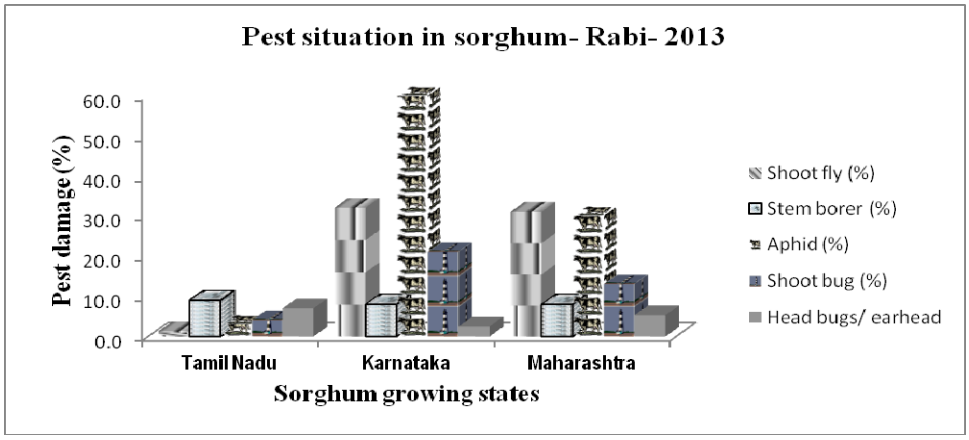

Table 1: Promising entries with less susceptibility to key pests of grain sorghum in different AICSIP trials- Rabi 2013-14 (Locations: 7)

Trial	Shoot fly (<40% DH)	Stem borer (<10% DH)	S. aphids (< 4.0 rating)	Shoot bug (< 2.0 rating)	Head bug < 3.0 rating)
AVHT-DS	Nil	SPH 1742, SPV 2228, SPH 1741, SPH 1744, SPV 2225, CSH 15 R and CSV 29	SSV 84, SPV 2221, SPV 2225, Hathi kuntha, SPH 1742	Hathi kuntha, CSH 15R, SPH 1746, SPH 1741	Hathi kuntha, SPH 1721 (2), SPV 2221, SPH 1746, CSV 22,
IHT-DS	Nil	SPH 1767	TAM 428	SPH 1767	SPH 1764, SPH 1765
IVT-DS	Nil	SPV 2274	SPV 2281, TAM 428, CSV 22, SPV 2278	SPV 2278, SPV 2274 , SPV 2277	SPV 2282, SPV 2276, CSH 15R, SPV 2281, SPV 2280, SPV 2277
IVHT-SS	Nil	SPH 1768, SPV 2288	SSV 84, Hathi kunta	Hathi kunta, TAM 428, Local check, CSH 15 R, SPV 2290, SPV 2288	Maulee
AICSIP-DS-SPN	SPV 2226	SPV 2213, SPV 2225, SPV 2226, local check	SPV 2140, SPV 2139, SPV 2217, SPV 2218, SPV 2228, TAM 428, d local check	Nil	SPV 2220, SPV 2229, IS 18551
AICSIP-SS-SPN	SPV 2230, SPV 2235 and SPV 2232	Nil	SPV 2236, SSV 84, TAM 428	Nil	SPV 2234, SPV 2231, IS 18551, SPV 2239, TAM 428
SFR (F_8)-DSR	EC 19 x EP 133-2-3, EG 15 x EP 57-6-1, CSV 22 x EC 12-4-1, LG Kumbhari local , EC 19, EC 15	POP 52, EC 19 x EP 133-2-3, EC 12 x POP 52-2-1, EC 12 x EP 133-5-2	DJ 6514, SSV 84, EC 19 x EP 133-2-3 and EC 12 X EP 133-5-2	Nil	Nil
IASFN (DSR)	RSV 1003, NRCSFR09-3, RSV 1315, RSE 03, RSV 1410, RSV 1507, RSV 1635, RSV 1698, RSV 1683, RSV 1687, PBN-ENT-2, PBN-ENT-3, PBN-ENT-4	RSV 1003, NRCSFR09-3, RSV 1315, RSE 03, RSV 1507, RSV 1607, RSV 1698, RPASV 25, Surthi	Nil	Nil	Nil
B & R lines	SLB 72, SLV 145	SLR 72, SLB 84	SLV 135, DJ 6514, SLR 71, SLB 59, SLB 55	Nil	Nil
ANGSN-SF (GP lines)	NSJB 6596, NSJB 6625, CJV 22, POP 39, SEB 11988	PEC 2, EP 100, CJV 11, POP 45, NSJB 6585, ELG 4	EP 80, EG 26, EG 24, NSJB 6629		
APSHN (DSR)	Nil	Nil	SLB 64, SLB 77, SLB 79, SLB 80, SLB 83, SLR 31, KR 191 and KR 196	SLB 19, CRS 11, Y 75, IS 2205 and B 35	Nil

Note: Underlined entries recorded as resistant/tolerance 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: Advance Varietal and Hybrid Trial for deep soil (AHVT-DS) (Locations: 7)

In AVHT-DS comprising 22 entries having 5 experimental hybrids, 6 experimental varieties, one commercial hybrid (CSH 15R), two commercial varieties (CSV 22, CSV 29R), one local cultivar (M 35-1), one respective local check from the center, three resistant checks (IS 18551, IS 2205, and TAM 428) and three susceptible checks (DJ 6514, SSV 84 and Hathi Kuntha) were evaluated for resistance to key pests at seven locations (Kovilpatti, Dharwad, Bijapur, Tandur, Rahuri, Parbhani, and Solapur).

Shoot fly (*Atherigona soccata,* Rond): Deadhearts caused by the shoot fly was recorded at peak stage at Bijapur, Dharwad, Tandur, Rahuri, Parbhani and Solapur. The data from Tandur was discarded as the susceptible check DJ 6514 recorded < 70% deadhearts. The data collected at Bijapur, Dharwad, Rahuri, Parbhani and Solapur were significant at 5% level across the locations and genotypes. The range was from 33.0 to 76.7% DH with an average of 50.0 % deadhearts. None of the test entries were on par with resistant check, IS 18551 at 28 DAE. However the entries SPV 2225 (43.9% DH), SPV 2221 (45.17 % DH) showed low damage (Table 1.1).

Oviposition preference: The Shoot fly eggs/ 5 plants were recorded at Bijapur, Dharwad, Tandur, Parbhani and Solapur at 14DAE. The data from Tandur and Parbhani is rejected due to exceptionally high CV (>26%). Across the locations and genotypes, the range was 2.60 – 11.47 eggs/ 5 plants averaging 4.80 eggs/ 5 plants. Overall, the entries SPH 1721(2), CSV 22, SPV 2227, SPH 1744, SPH 1742, CSV 29R, CSH 15R and SPV 2144(2) recorded relatively low plant infestation (3.67 – 4.27 eggs/ 5 plants and were significantly superior to DJ 6514 (SC) (Table 1.1).

Morpho-physiological traits: The morpho-physiolgical traits such as seedling vigor and leaf glossiness (rating 1-5) were recorded at Kovilpatti, Bijapur, Dharwad, Tandur and Rahuri, Parbhani and Solapur Across the locations, the entries SPH 1721 (2) showed glossiness score of 2.45 and was on par with IS 18551 (RC). The entries SPH 1741, SPV 2221, and SPH 1744 showed low rating (<2.7). Across locations and genotypes the entries SPV 2227, SPH 1746, CSV 22, SPV 2221 recorded seedling vigor score (<3.0) (Table 1.3).

Spotted stem borer (Chilo partellus, Swinhoe*):* The data on stem borer was recorded at four centers. 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, stem tunneling (%) and peduncle damaged plants (%) at hot spot locations. The data on percent leaf injury was recorded at 35 DAE at Kovilpatti, Tandur, Rahuri. The damage was very low (<3.56 %). Data from all the centers recorded exceptionally high CV (> 25%). Across the genotypes, locations the data on leaf damage percentage ranged from 1.22 – 3.56 % the average being 2.04 %. Amongst test entries, CSV 29 R, SPV 2215, SPH 1721(2) recorded less than 1.50 % leaf injury (Table 1.2). The data on deadhearts at 45 DAE was recorded at Tandur and Parbhani. The overall mean of deadhearts % due to stem borer at 45 DAE was ranged from 4.9 – 19.3 % DH the average being 11.44 %. Across the locations and genotypes, SPH 1742, SPV 2228, SPH 1741, SPH 1744, SPV 2225, CSH 15 R and CSV 29 recorded low deadhearts (<10%). The stem tunneling data was recorded at Kovilpatti only and had high CV%. The damage ranged from 23.2 – 70.7 % with mean tunneling of 43.3 % (Table1.2).

Shoot bug (Peregrines maidis, Ashmead*):* Data on damage rating plant damage due to shoot bug was recorded at Bijapur. Across the location the range was from 1.0-4.67 the average being 2.29. Data was not sign. at 5% level. Hathi kunta, CSH 15R, SPH 1746, SPH 1741 recorded low damage score (1.33) (Table 1.2).

Sugarcane aphid (*Melanaphis sacchari,* Zehntner): The data on plant damage rating (1-9) due to sugarcane aphid was recorded at Bijapur Rahuri and Parbhani. Across the location the damage rating was low and ranged from 4.11 -5.78 being an average of 5.2. The entries SSV 84, SPV 2221, SPV 2225, Hathi kunta, SPH 1742 recorded damage less than 5.0 and were on par with TAM 428 (RC).(Table 1.2).

Head bug (*Calocoris angustatus):* The data on damage rating due to head bug was recorded at Kovilpatti and Tandur. The data was not significant at 5% level and had high CV%. Overall, the range was from 2.17 to 5.17 being an average of 3.52. Numerically, the test entries Hathi kuntha, SPH 1721 (2), SPV 2221, SPH 1746, CSV 22, and local check recorded up to 3 damage rating due to head bug (Table 1.1).

Plant stand per plot (1.2 m^2): The data on plant population per plot (2 rows of 2 m=1.2 m^2) was recorded at Kovilpatti, Dharwad, Tandur, Parbhani and Solapur. Across the genotypes and locations, the data on plant population was not significant and ranged from 20 to 25 plants being an average of 22.5 plants plot^{-1} (Table 1.4).

Day to (50%) flowering: Days to 50% flowering were recorded at three centers; Tandur, Bijapur and Dharwad. The data was significant between the genotypes and across the locations. Overall, shortest duration to flower was recorded in SPH 1721 (70 days) and the longest flowering was recorded in DJ 6514 (86 days) and overall mean days to flower was 74 days (Table 1.4).

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 Parbhani and Solapur. Overall, the range was 64 to 244 g with a mean of 157 g plant $^{-5}$. However the data was not statistically significant at 5% level. Irrespective of locations and the genotypes, the higher grain yield was obtained in SPV 2221 (244 g/ plant^{-5}) and the lowest was recorded in DJ 6514 (64 g) (Table 1.4).

Overall resistant rating: The data on overall rating on resistance was recorded at Tandur and Parbhani. Across the locations and genotypes, the data was not significant at 5% level. The range of resistance rating was from 5.50- 6.83 with an average of 5.95 in the scale of 1-9. None of the entries recorded high resistant recovery even below 5 rating. The good resistance recovery was recorded in resistance check IS 18551 (Table 1.4).

Trial 2: Initial Hybrid Trial for Deep Soil (IHT-DS) (Location: 7)

In IHT-DS trial, total sixteen entries having six experimental hybrids, one commercial hybrid (CSH 15R), two commercial varieties (CSV 22, CSV 29R), one local check from respective centers, three resistant checks (IS 18551, IS 2205, and TAM 428) and three susceptible checks (DJ 6514, SSV 84 and Hathi Kuntha) were evaluated for resistance to key pests at seven locations (Kovilpatti, Dharwad, Bijapur, Tandur, Rahuri, Parbhani, and Solapur).

Shoot fly (*Atherigona soccata,* Rond): Deadhearts caused by the shoot fly was recorded at peak stage of the infestation of shoot fly involving centers viz; Kovilpatti, Bijapur, Dharwad, Tandur, Rahuri, Parbhani and Solapur. The data on shoot fly deadhearts recorded at all locations were significant at 5% level. Across the locations and genotypes the range was from 33.0 to 78.2% deadhearts with an average of 54.6% deadhearts. None of the test entries was superior than resistant check IS 18551(Table 2.1).

Oviposition preference: The Shoot fly eggs/ 5 plants were recorded at Kovilpatti, Bijapur, Dharwad, Tandur, Parbhani and Solapur at 14DAE. The data from Kovilpatti, Bijapur, Dharwad and Tandur was rejected due to exceptionally high CV (>25%). Across the locations and genotypes, the range was 2.69 – 7.58 eggs/ 5 plants averaging 3.72 eggs/ 5 plants. Overall, the test entry SPH 1762 recorded lowest eggs on five plants after resistant checks IS 18551. However, the data was not significant and had high CV% (Table 2.1).

Morpho-physiological traits: The morpho-physiolgical traits such as seedling vigor and leaf glossiness (rating 1-5) were recorded at Kovilpatti, Bijapur, Dharwad, Rahuri, Tandur, Parbhani and Solapur. The entries that recorded high seedling vigour are CSV 29R, LC, SPH 1764 and high glossiness in SPH 1767, SPH 1763, and SPH 1764 (<2.8) (Table 2.2).

Spotted stem borer (Chilo partellus, Swinhoe*):* The data on spotted stem borer infestation was assessed in terms of leaf injury plants (1-9) at 30 DAE, deadhearts (%) at 45 DAE, stem tunneling (%) and peduncle damaged plants (%) at hot spot locations. The data on leaf damage due stem borer was recorded at 30 DAE at Tandur, Kovilpatti and Rahuri. Across the genotypes, the data on leaf damage rating was not significant and had high CV%. It ranged from 1.44-3.67 being an average of 2.00. Amongst test entries, SPH 1763, SPH 1764, SPH 1767 and Hathi kuntha recorded lowest leaf damage rating due to stem borer (< 2) and numerically at par with resistant check IS 2205. The data on deadhearts at 45 DAE was recorded at Kovilpatti and Parbhani center. The overall mean of deadhearts % due to stem borer at 45 DAE was ranged from 4.5- 25.5% being an average of 9.2%. Across the locations and genotypes, the data was not insignificant at 5% level. However, the test entries SPH 1767 recorded lowest deadhearts (4.9%) (Table 2.2). The peduncle tunneling (%) was recorded in Kovilpatti only. Across the genotypes, peduncle tunneling (%) ranged from 9.7 – 95.0 % with an average of 41.3%. However, the data was not significant at 5% level. The least damage was recorded in Hathi kuntha (Table 2.2).

Shoot bug (*Peregrines maidis,* Ashmead*):* The data on plant damage rating due to shoot bug was recorded at Bijapur only. Across the location the range was from 1.00 to 3.00 being an average of 2.00. The data was not

significant at 5% level and had high CV%. The entry SPH 1767 recorded lowest plant damage rating (1.0) due to shoot bug (Table 2.2).

Sugarcane aphid (*Melanaphis sacchari,* Zehntner): The data on plant damage rating (1-9) due to sugarcane aphid was recorded at Bijapur, Parbhani and Rahuri. Across the location the damage rating was moderate and ranged from 4.0-5.7 being an average of 4.9. However, the data was not significant at 5% level. Across the locations, TAM 428 recorded lowest damage rating 4.0 (Table 2.2) (Table 2.2).

Head bug (*Calocoris angustatus):* The data on damage rating (1-9) due to head bug was recorded at Kovilpatti and Tandur. Overall, it was moderate and the data was not significant at 5% level and had high CV%. The range was from 1.50 to 3.33 being an average of 2.49. The entries SPH 1764 and SPH 1765 recorded < 2 damage rating (Table 2.1).

Plant stand per plot (1.2 m^2): The data on plant population/ per plot (2 rows of 2 m=1.2 m^2) was recorded at Kovilpatti, Dharwad, Tandur, Parbhani & Solapur. Across the genotypes and locations, the data on plant population was significant and ranged from 18.9 to 25.6 plants/plot with an average of 22.0 plants plot^{-1} (Table 2.4).

Day to (50%) flowering: Days to 50% flowering were recorded at four centers i.e., Tandur, Rahuri and Parbhani. Across the locations and genotypes the shortest duration to flower was recorded in Hathi kuntha (71 days) and the longest was recorded in DJ 6514 (86 days). The data was statistically significant at 5% level (Table 2.4).

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 Parbhani and Solapur. Overall, the range was 63 to 212 g with a mean of 142 g plant $^{-5}$. However the data was statistically significant at 5% level. Irrespective of locations and the genotypes, the higher grain yield was obtained in SPH 1764 (212 g/ plant^{-5}) and the lowest was recorded in DJ 6514 (63 g) (Table 2.4).

Overall resistant rating: The data on overall rating on resistance was recorded at Tandur and Parbhani. Across the locations and genotypes, the data was not significant at 5% level. The range of resistance rating was from 5.17- 6.67 with an average of 5.85 in the scale of 1-9. None of the entries recorded high resistant recovery even below 5 rating. The good resistance recovery was recorded in resistance check IS 18551 (Table 2.4).

Trial 3: Initial Varietal Trial for deep soil (IVT-DS) (Location: 7)

In IVT-DS trial, total twenty four entries having fourteen experimental varieties, one commercial hybrid (CSH 15R), two commercial varieties (CSV 22, CSV 29R), one local check from respective centers, three resistant checks (IS 18551, IS 2205, and TAM 428) and three susceptible checks (DJ 6514, SSV 84 and Hathi Kuntha) were evaluated for resistance to key pests at seven locations (Kovilpatti, Dharwad, Bijapur, Tandur, Rahuri, Parbhani, and Solapur).

Shoot fly (*Atherigona soccata,* Rond): Deadhearts caused by the shoot fly was recorded at peak stage of the infestation of shoot fly involving centers viz; Kovilpatti, Bijapur, Dharwad, Tandur, Rahuri, Parbhani and Solapur. The data on shoot fly deadhearts recorded at all locations were significant at 5% level except Bijapur. Across the locations and genotypes the range was from 34.43 to 79.31% deadhearts with an average of 55.93% deadhearts. None of the test entries was superior to resistant check IS 18551 (Table 3.1).

Oviposition preference: The Shoot fly eggs/ 5 plants were recorded at Bijapur, Dharwad, Tandur, Parbhani and Solapur at 14DAE. The data from all centers except Bijapur had high CV%. But the data at Bijapur was not significant at 5% level. Across the locations and genotypes, the range was 2.53 – 8.40 eggs/ 5 plants averaging 4.46 eggs/ 5 plants. Overall, the test entry SPV 2284, recorded lowest eggs on five plants after resistant checks IS 18551. However, the data had high CV% (Table 3.1).

Morpho-physiological traits: The morpho-physiolgical traits such as seedling vigor and leaf glossiness (rating 1-5) were recorded at Kovilpatti, Bijapur, Dharwad, Rahuri, Tandur, Parbhani and Solapur. The entries that recorded high seedling vigor are SPV 2279, CSV 22 and local check (<3) and high glossiness rating in SPV 2274, SPV 2276, SPV 2287 and SPV 2285 (< 3) (Table 3.3).

Spotted stem borer (Chilo partellus, Swinhoe*):* The data on spotted stem borer infestation was assessed in terms of leaf injury plants (1-9) at 30 DAE, deadhearts (%) at 45 DAE, stem tunneling (%) and peduncle damaged plants (%) at hot spot locations. The data on leaf damage due stem borer was recorded at 30 DAE at Tandur and Kovilpatti. Across the genotypes, the data on leaf damage rating was not significant and had high CV%. It ranged from 1.67 to 4.00 being an average of 2.56. Amongst test entries, SPV 2285 and SPV 2275

recorded lowest leaf injury rating after resistant check IS 2205 (1.67) and numerically at par with resistant check IS 2205 (Table 3.2). The data on deadhearts at 45 DAE was recorded at Parbhani center. The overall mean of deadhearts % due to stem borer at 45 DAE was ranged from 4.1- 10.1% being an average of 7.1%. Across the locations and genotypes, the data was not insignificant at 5% level and high CV %. However, the test entries SPV 2274 recorded lowest deadhearts (<5%) and numerically equal to IS 2205 (Table 3.2). The peduncle tunneling (%) was recorded in Kovilpatti only. Across the genotypes, peduncle tunneling (%) ranged from 11.0 – 96.7 % with an average of 46.1%. The data was significant at 5% level but had high CV%. The least damage was recorded SPV 2277 (11.0%) (Table 3.2).

Shoot bug (*Peregrines maidis,* Ashmead)*:* The data on plant damage rating due to shoot bug was recorded at Bijapur only. Across the location the range was from 1.33 to 3.00 being an average of 2.25. The data was not significant at 5% level and had high CV%. The entries SPV 2278, SPV 2274 and SPV 2277 recorded lowest plant damage rating (< 1.7) due to shoot bug (Table 3.2).

Sugarcane aphid (*Melanaphis sacchari,* Zehntner): The data on plant damage rating (1-9) due to sugarcane aphid was recorded at Bijapur, Rahuri and Parbhani. Across the locations the data on damage rating was significant at 5% level. The data varied from 4.56 to 6.33 being an average of 5.54%. Across the locations and genotypes, the entries SPV 2281, TAM 428, CSV 22 and SPV 2278 recorded lowest damage rating <5.0 damage rating (Table 3.2).

Head bug (*Calocoris angustatus):* The data on damage rating (1-9) due to head bug was recorded at Kovilpatti and Tandur. The damage rating had very narrow range. An overall, it was varied from 2.50 to 4.17 with an average of 3.27. However, the data was non-significant at 5% level. The entries SPV 2282, SPV 2276, CSH 15R, SPV 2281, SPV 2280 and SPV 2277 recorded low damage rating (< 2.7) (Table 3.1).

Day to (50%) flowering: Days to 50% flowering were recorded at three centers i.e., Tandur, Rahuri, Parbhani. Across the locations and genotypes the shortest flowering period was recorded in Hathi kuntha (72 days) and the longest flowering was noticed in DJ 6514 (86 days). The data was statistically significant at 5% level (Table 3.4).

Overall resistant rating: The data on overall rating on resistance was recorded at Tandur and Parbhani. Across the locations and genotypes, the data was not significant at 5% level. The range of resistance rating was from 5.50- 6.50 with an average of 6.15 in the scale of 1-9. None of the entries recorded high resistant recovery even below 5 rating. Relatively the good resistance recovery was obtained in SPV 2276 (Table 3.4).

Plant stand per plot (1.2 m^2): The data on plant population per plot (2 rows of 2 m) was recorded at Kovilpatti, Dharwad, Tandur, Parbhani and Solapur. Across the genotypes and locations, the data on plant population was significant and ranged from 20.1 to 25.1 plants with an average of 22.3 plants $plot^{-1}$. The highest plant population was recorded in CSV 22, while lowest plant stand was recorded in CSH 15R (201 plant (Table 3.4).

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 Parbhani and Solapur. Overall, the range was 69 to 244 g with a mean of 168 g $plant^{-5}$. However the data was not statistically significant at 5% level and had high CV%. Irrespective of locations and the genotypes, the highest grain yield was obtained in SSPV 2277 (244g/ $plant^{-5}$) and the lowest was recorded in DJ 6514 (69 g) (Table 3.4).

Trial 4: Initial Varietal and Hybrid Trial for shallow soil (IVHT-SS) (Location: 7)

In IVHT-DS trial, total eighteen entries having four experimental verities, two experimental hybrids, one commercial hybrid (CSH 15R), two commercial varieties (CSV 26, Phule Anuradha), two local varieties (M 35-1, Maulee), one local check from respective centers, three resistant checks (IS 18551, IS 2205, and TAM 428) and three susceptible checks (DJ 6514, SSV 84 and Hathi Kuntha) were evaluated for resistance to key pests at seven locations (Kovilpatti, Dharwad, Bijapur, Tandur, Rahuri, Parbhani, and Solapur).

Shoot fly (*Atherigona soccata,* Rond): Deadhearts caused by the shoot fly was recorded at 28 DAE in Bijapur, Dharwad , Tandur, Parbhani and Solapur. The data from Bijapur, had to be rejected as the susceptible check DJ 6514 recorded < 70% deadhearts. The shoot fly deadhearts ranged from 36.4 – 78.6 % the mean being 57.6 % DH. Across the locations none of the entry was on par with resistant check IS 18551. The test entries recorded over 51.0 % DH indicating that they were highly susceptible as compared to resistant check which recorded 36.4 % DH.. (Table 4.1).

Oviposition preference: Oviposition by the shoot fly was recorded at 14 DAE in Bijapur, Dharwad , Tandur, Parbhani and Solapur. The data from all the locations had to be rejected as the susceptible check DJ 6514 recorded < 70% deadhearts.. The CV was exceptionally high at Bijapur, Dharwad, Parbhani, abd Solapur.. The range was from 2.60 – 9.67 % DH with an average of 4.36 % DH. The entries SPH 1769, SPV 2290, SPV 2291 lower no. og eggs/5 plants (Table 4.1).

Morpho-physiological traits: The morpho-physiolgical traits such as seedling vigor and leaf glossiness (rating 1-5) were recorded at Kovilpatti, Bijapur, Dharwad, Tandur Rahuri, Parbhani and Solapur. None of the entries were on par with resistant check. The score ranged from 2.33 – 3.95, the average being 3.16.The entries SPV 2288, showed glossiness score of 3.00 rest of the entries recorded score over 3.00. The seedling vigour score ranged from 2.81 – 3.52, the average being 3.11. The entries Phule Anuradha, SPV 2289CSH 15R and SPH 1769 recorded seedling vigour score (<3.0) (Table 4.3).

Spotted stem borer (Chilo partellus, Swinhoe*):* The data on stem borer was recorded at three centers. The data on spotted stem borer infestation was assessed in terms of leaf injury plants damage rating (1-9), deadhearts (%) at 45 DAE, stem tunneling (%) damaged plants (%) at hot spot locations. The data on percent leaf injury was recorded at 35 DAE at Kovilpatti, Tandur and Rahuri. The damage was very low. Data from all the centers recorded exceptionally high CV (> 25%). Across the genotypes, locations the data on leaf damage rating ranged from 1.0 – 3.33 the average being 1.75. Amongst test entries, Local checks, Hathi kunta, Phule Anuradha, SPV 2288 recorded low damage ratings (Table 4.2). The data on dead hearts at 45 DAE was recorded at Kovilpatti and Parbhani. The overall mean of deadhearts % due to stem borer at 45 DAE was ranged from 4.79 – 11.36 % DH the average being 7.52 %. The CV was high (> 25.0%) at both the locations. The entries SPH 1768, SPV 2288 recorded lower damage. The stem tunneling ranged from 10.4 – 95.0 % with average of 47.0 % but the Cv was exceptionally high to be considered. (Table.4.2).

Shoot bug (Peregrines maidis, Ashmead*):* The data on damage rating plant damage due to shoot bug was recorded at Bijapur. The range was from 1.0 – 2.33, the average being 1.56. The data was not significant at 5% level. Hathi kunta, TAM 428, Local check, CSH 15 R, SPV 2290 and SPV 2288 recorded low scores (1.33). (Table 4.2).

Sugarcane aphid (*Melanaphis sacchari,* Zehntner): The data on plant damage rating (1-9) due to sugarcane aphid was recorded at Bijapur Rahuri and.Parbhani. Across the location the damage rating was low and ranged from 4.11 -6.00 being an average of 5.49. The entries SSV 84, Hathi kunta, recorded damage less than 5.0 and were on par with (RC).(Table 4.2).

Head bug (*Calocoris angustatus) :* The data on damage rating due to head bug was recorded at Kovilpatti and Tandur. It was very low and the data was not significant at 5% level. The score ranged from 1.00 to 2.67 with an average of 1.81. Maulee recorded lowest damage rating (1.00) (Table 4.1).

Day to (50%) flowering: Days to 50% flowering were recorded at four centers i.e., Tandur, Rahuri and Parbhani. Across the locations and genotypes the earliest to flower was Phule Anuradha (71 days) and DJ 6514 was late flowering (82.1 days).. The data was statistically significant at 5% level (Table 4.4).

Overall resistant rating: The data on overall rating on resistance was recorded at Tandur and Parbhani. Across the locations and genotypes, the data was not significant at 5% level. The range of resistance rating was from 6.00- 6.83 with an average of 6.44 in the scale of 1-9. None of the entries recorded high resistant recovery even below 5 rating (Table 4.4).

Plant stand per plot (1.2 m^2): The data on plant population per plot (2 rows of 2 m=1.2 sqm) was recorded at Kovilpatti, Dharwad, Tandur, Parbhani and Solapur. Across the genotypes and locations, the data on plant population was significant and ranged from 19.3 to 24.2 plants being an average of 28 plants $plot^{-1}$ (Table 4.4).

Grain yield (g) per plant: Grain yield in grams per plant was assessed on the basis mean of 5 plant samples per plot and recorded at Parbhani and Solapur. Overall, the range was 78 to 223 g with a mean of 149 g $plant^{-5}$. However the data was not statistically significant at 5% level. Irrespective of locations the mean higher grain yield was obtained in SPH 1769 (223 g/ $plant^{-5}$) and the lowest was recorded in DJ 6514 (78 g/ $plant^{-5}$) (Table 4.4).

Trial 5: Selections from AICSIP trials for deep soil (AICSIP-DS-SPN) (Location: 7)
In AICSIP-DS-SPN, total twenty entries having sixteen selections, two resistant checks (IS 18551 and TAM 428) one susceptible check (Swarna) and one local check from respective centers were evaluated for resistance to key pests at seven locations (Kovilpatti, Dharwad, Bijapur, Tandur, Rahuri, Parbhani, and Solapur).

Shoot fly (*Atherigona soccata,* Rond): Deadhearts caused due to shoot fly at peak stage was recorded at Dharwad, Tandur, Rahuri, Parbhani and Solapur. The data from Rahuri and Tandur was discarded as DJ 6514 (Susceptible check) recorded < 70% deadhearts and had high CV%. Across the locations and genotypes, the deadhearts % range was from 40.1 to 81.6 % being an average of 61.5%. The data was significant at 5% level. The entries SPV 2226 recorded low deadhearts % (50.8 %) and did not differed from resistant check IS 18551 (Table 5.1).

Morpho-physiological traits: The data on morpho-physiolgical traits such as seedling vigor and leaf glossiness were recorded at Kovilpatti, Tandur, Rahuri, Parbhani and Solapur in the scale of 1-5. The data on seedling vigor and glossiness was significant at 5% level. Across the locations and genotypes, the range of leaf glossiness rating was from 2.44 to 4.00 with an average of 3.09. The entries recorded high glossiness (<3) are SPV 2140, SPV 2139, SPV 2152, SPV 2212, SPV 2222, SPV 2225, SPV 2228 and SPV 2229. The data on seedling vigor was ranged from 2.28 to 3.61 with an average of 2.81. The entries that recorded high vigor was SPV 2218. However the data was not significant at 5% level (Table 5.2).

Spotted stem borer (*Chilo partellus,* Swinhoe) :The data on spotted stem borer infestation was assessed in terms of leaf injury rating (1-9) at 30 DAE, deadhearts (%) at 45 DAE and stem tunneling (%) at hot spot locations viz; Kovilpatti, Rahuri, Tandur, Rahuri and Parbhani. The data on stem borer leaf injury rating (1-9) was recorded at Kovilpatti, Rahuri and Tandur. All locations had high CV%. Overall, the damage ranged from 1.6 – 3.6 with an average of 2.4 in the scale of 1 to 9. The lowest leaf injury was recorded in SPV 2213. However, the data had high CV% and non-significant at 5% level (Table 5.1).The data on tunneling damage (%) due to stem borer was recorded at Kovilpatti only. The data was significant at 5% level. The range was from 39.8 to 80.9 with an average of 60.6%. The lowest tunneling was recorded in SPV 2224 (39.8%) and was on par with resistant check (Table 5.1). Deadhearts caused by borer was recorded at Parbhani and Tandur. Across the locations and the genotypes the range of deadhearts was from 3.19-13.3 % with an average of 7.2 % deadhearts. Across the locations, the data was not significant at 5% and had high CV%. The lowest (< 6%) deadhearts due to stem borer was recorded in SPV 2213,SPV 2225, SPV 2226 and local check (Table 5.1).

Sugarcane aphid (*Melanaphis sacchari,* Zehntner) :Plant damage due to sugarcane aphid was recorded in the scale of 1-9 at Parbhani and Tandur. Overall, the plant damage rating due to aphid was ranged from 2.8 to 5.5 being an average of 4.3. Across the locations, the lowest (< 4) plant damage was recorded in SPV 2140, SPV 2139, SPV 2217, SPV 2218, SPV 2228, TAM 428 and local check (Table 5.3).

Head bug (*Calocoris angustatus):* The data on damage rating (1-9) due to head bug at milk stage was recorded at Kovilpatti and Rahuri. However the data was not significant at 5% level across the locations. Overall, the data ranged from 2.67 to 5.00 averaging 3.66 damage rating. The lower damage rating (<3) was recorded in SPV 2220, SPV 2229 and IS 18551 (Table 5.3).

Day to (50%) flowering: The data on days to 50% flowering were recorded at Tandur, Rahuri and Parbhani. The range was from 72.3 to 82.4 days to flowering with a mean of 76.8 days. The entry SPV 2218 recorded longest flowering of 82.4 days and TAM 428 recorded earliest flowering 72.3 days (Table 5.2).

Overall resistant rating: The data on overall rating on resistance was recorded at Parbhani and Tandur. Across the locations and genotypes, the range was from 5.17- 7.33 with an average of 6.21. None of the test entries recorded high resistant rating (Table 5.3).

Plant stand per plot (1.2 m^2): The data on plant population per plot (2 rows of 2 m) was recorded at Kovilpatti, Dharwad, Tandur, Parbhani and Solapur. Across the genotypes and locations, the data on plant population per plot was significant and ranged from 12.6 to 24.3 plants being an average of 17.0 plants $plot^{-1}$. The highest plant population was recorded in IS 18551 and lowest was in SPV 2224 (Table 5.3).

Trial 6: Selections from AICSIP trials for shallow soil (AICSIP-SS-SPN) (Location: 7)
In AICSIP-SS-SPN, total sixteen entries having eight selections, four resistant checks (IS 18551, IS 2205, TAM 428 and Y 75), three susceptible checks (Swarna, SPV 84 and Hathi kuntha) and one local check from respective centers were evaluated for resistance to key pests at seven locations (Kovilpatti, Dharwad, Bijapur, Tandur, Rahuri, Parbhani, and Solapur).

Shoot fly (*Atherigona soccata,* Rond): Deadhearts caused due to shoot fly at peak stage was recorded at Dharwad, Tandur, Rahuri, Parbhani and Solapur. The data from Rahuri and Tandur was discarded as DJ 6514 (Susceptible check) recorded < 70% deadhearts and had high CV%. Across the locations and genotypes, the deadhearts % range was from 39.3 to 782 % being an average of 59.5%. The data was significant at 5% level. The entries SPV 2230, SPV 2235 and SPV 2232 recorded low deadhearts % (< 52 %) and did not differed from resistant check IS 18551 (Table 6.1).

Oviposition preference: The data on eggs laid on five plants at 14 DAE were recorded at Dharwad, Parbhani, Solapur and Tandur. Overall the data was statistically significant at 5% level but had high CV%. Across the locations, the no of eggs on five plants was ranged from 2.50 to 7.42 eggs/5 pts with the average being 4.58 eggs. The test entries SPV 2230, SPV 2235, and local check recorded <4 eggs/5 pts and were less preferred for oviposition (Table 6.1)

Morpho-physiological traits: The data on morpho-physiolgical traits such as seedling vigor and leaf glossiness were recorded at Kovilpatti, Tandur, Rahuri, Parbhani and Solapur in the scale of 1-5. The data on seedling vigor and glossiness was significant at 5% level. Across the locations and genotypes, the range of leaf glossiness rating was from 2.24 to 3.84 with an average of 3.13. The entry that recorded high glossiness (<3) was SPV 2230. The data on seedling vigor was ranged from 2.82 to 3.41 with an average of 3.12. The entries that recorded high seedling vigor was SPV 2230, SPV 2232, SPV 2236, SPV 2237 and TAM 428. However the data was not significant at 5% level (Table 6.2).

Spotted stem borer (*Chilo partellus,* Swinhoe) :The data on spotted stem borer infestation was assessed in terms of leaf injury rating (1-9) at 30 DAE, deadhearts (%) at 45 DAE and stem tunneling (%) at hot spot locations viz; Kovilpatti, Rahuri, Tandur, Rahuri and Parbhani. The data on stem borer leaf injury rating (1-9) was recorded at Kovilpatti and Rahuri. Kovilpatti had had high CV%. Overall, the injury ranged from 1.5 – 2.5 with an average of 2.1 in the scale of 1 to 9. The lowest leaf injury was recorded in SPV 2234. However, the data had high CV% and non-significant at 5% level (Table 6.1).The data on tunneling damage (%) due to stem borer was recorded at Kovilpatti only. The data was significant at 5% level but had high CV%. The range was from 26.9 to 85.6 with an average of 60.1%. The lowest tunneling was recorded in SPV 2230 (26.9%) and was on par with resistant check (Table 6.1). Deadhearts caused by stem borer was recorded at Parbhani and Tandur. Across the locations and the genotypes the range of deadhearts was from 3.72-10.22 % with an average of 7.30 % deadhearts. Across the locations, the data was not significant at 5% and had high CV%. None of the test entries performed better than resistant check (Table 6.1).

Sugarcane aphid (*Melanaphis sacchari,* Zehntner) :Plant damage due to sugarcane aphid was recorded in the scale of 1-9 at Parbhani only. Overall, the plant damage rating due to aphid was ranged from 3.00 to 7.33 being an average of 5.65. The data was significant at 5% level. The lowest (< 4) plant damage was recorded in SPV 2236, SSV 84 and TAM 428 (Table 6.2).

Head bug (*Calocoris angustatus):* The data on damage rating (1-9) due to head bug at milk stage was recorded at Kovilpatti and Rahuri. Overall, the plant damage rating due to aphid was ranged from 2.00 to 4.83 being an average of 3.22. However the data was not significant at 5% level and had high CV%. Across the locations, the lowest (< 3) plant damage was recorded in SPV 2234, SPV 2231, IS 18551, SPV 2239 and TAM 428 (Table 6.2).

Day to (50%) flowering: The data on days to 50% flowering were recorded at Tandur, Rahuri and Parbhani. Across the locations, the range was from 73.4 to 82.0 days to flowering with a mean of 76.7 days. The entry SPV 2236 recorded longest flowering of 82.0 days and SPV 2235 recorded earliest flowering 73.4 days (Table 6.3).

Overall resistant rating: The data on overall rating on resistance was recorded at Parbhani and Tandur. Across the locations and genotypes, the range was from 3.33- 6.67 with an average of 5.40. None of the test entries recorded high resistant rating (Table 6.3).

Plant stand per plot (1.2 m^2): The data on plant population per plot (2 rows of 2 m) was recorded at Kovilpatti, Dharwad, Tandur, Parbhani and Solapur. Across the genotypes and locations, the data on plant population per plot was significant and ranged from 16.47 to 23.3 plants being an average of 19.9 plants plot^{-1}. The highest plant population was recorded in IS 18551 and lowest was in SPV 2232 (Table 6.3).

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 Parbhani and Solapur. Overall, the range was from 76 to 258 g with a mean of 157 g plant^{-5}. The data was not statistically significant at 5% level and had high CV%. Irrespective of locations and the genotypes, the higher grain yield was obtained in SPV 2232 (258 g/ plant^{-5}) and the lowest was recorded in Y 75 (76 g) (Table 6.3).

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

Trial 7: Evaluation of SFR-F$_8$ lines for shoot fly resistance (SFR-F$_8$) (Locations: 4)

Out of 90 crosses, fourteen crosses were evaluated (selected from F5 progenies Rabi 2010) developed by Germplasm Unit, DSR, Hyderabad for evaluating shoot fly resistance at diverse environmental conditions. A three replicated trial was conducted at Rahuri, Parbhani, Solapur and Hyderabad during Rabi 2013-14. It comprises twenty entries having eight crosses, eight parental lines, one local check from respective centers, 1 resistant check (IS 2312), two susceptible checks (DJ 6514, SSV 84). The trial was sown in 2 rows of 2 m each under artificial conditions by using fish meal screening technique. The observations were recorded on shoot fly deadhearts at peak stage. The data were also collected on seedling vigor, glossiness, seedling (%) infested with eggs and other agronomic characters like days to flowering at 50%, plant height and grain yield (g)/plant.

Shoot fly (*Atherigona soccata,* Rond): Deadhearts caused by shoot fly at peak period were recorded at Rahuri, Parbhani, Solapur and Hyderabad. At Rahuri, the data of susceptible check DJ 6514 was <70% and hence could not consider. At Parbhani, the range was from 49.1 to 98.4% with an average of 72.6%. The entries CSV 22 x EC 12-4-1, LG Kumbhari local, EC 19 and EC 15 recorded lowest deadhearts % and was on par with resistant check. At Solapur, the deadheart range was from 26.8 to 70.3% with an average of 38.4%. The entries that recorded lowest deadhearts% are (PEC 1 x LG Kumbhari local) x EC 19-6-2, EC 12x EP 133-5-2, EC 15 X EP 57-6-1, and EC 12. At Hyderabad the range of deadhearts % were 26.6 to 70.3% with an average of 37.3%. The entries recorded lowest deadhearts are EC 12 x POP 52-3-1, (PEC 1 x LG Kumbhari local) x EC 19-6-2, (PEC 1 x LG Kumbhari local) x EC 15-7-1, PEC 1, EC 19, and EP 133. The data were significant at 5% irrespective of locations. Across the locations and genotypes, the deadheart % range was from 35.6 to 79.7% being an average of 49.4%. The data was statistically significant at 5%. Almost all entries were on par with resistant check IS 2312. The progenies that recorded lowest deadhearts (<45%) are EC 19 x EP 133-2-3, EG 15 x EP 57-6-1, CSV 22 x EC 12-4-1 and the parental lines that recorded lowest (<45%) deadhearts % are LG Kumbhari local , EC 19 and EC 15 (Table 7.1).

Oviposition preference: The data on eggs laid on five plants at 14 DAE were recorded at Parbhani, Solapur and Hyderabad. Overall the data was statistically significant at 5% level. Across the locations, the no of eggs on five plants was ranged from 3.06 to 8.78 eggs/5 pts with the average being 4.40 eggs. The progenies EC 12 x POP 52-3-1, EC 12 x EP 133-5-2, (PEC 1 x LG kumbhari local) x EC 19-6-2, (PEC 1 x LG kumbhari local) x EC 15-7-1 were less preferred for oviposition and were on par with resistant check IS 2312 (Table 7.1)

Spotted stem borer (*Chilo partellus,* Swinhoe) :The data on spotted stem borer infestation was assessed in terms of leaf injury rating (1-9), deadhearts (%) at 45 DAE, stem tunneling (%) and peduncle damage (%) at Parbhani and Hyderabad. Deadhearts caused by borer was recorded at Parbhani and Hyderabad. The range of deadhearts was from 5.1 – 16.2 % with an average of 8.3% deadhearts. Across the locations, the data was not significant at 5% and had high CV%. The lowest (<6%) deadhearts due to stem borer was recorded in POP 52, EC 19 x EP 133-2-3, EC 12 x POP 52-2-1 and EC 12 x EP 133-5-2 (Table 7.1). The data on Stem borer leaf injury rating (1-9) was recorded at Hyderabad. The damage ranged from 1.67 – 5.67 with an average of 4.00 in the scale of 1 to 9. The lowest leaf injury was recorded in EC 12 x POP 52-2-1, (PEC 1 x LG Kumbhari local) x EC 15-7-1, EC 19 x EP 133-2-3, and PEC 1 and was on par with resistant check. However, the data had high CV% (Table 7.1)

Morpho-physiological traits: Morpho-physiolgical traits such as seedling vigor and leaf glossiness have been recorded at Rahuri, Parbhani, Solapur and Hyderabad in the scale of 1-5. Across the locations, the data on leaf glossiness was significant at 5%. The highest glossiness was recorded in EC 15, followed by POP 52,SSV 84 x

POP 52-3-1, EC 12 x EP 133-5-2, (PEC 1 x LG kumbhari local) x EC 19-6-2. Across the locations the data on seedling vigor was not significant at 5%. The highest vigor was recorded in (PEC 1 x LG kumbhari local) x EC 15-7-1 and followed by PEC 1(Table 7.2).

Sugarcane aphid (*Melanaphis sacchari),* Zehntner: The data on sugarcane aphid damage on 1-9 scale was recorded at Rahuri and Parbhani. The damage ranged from 4.2 – 5.2 with an average of 4.7. The data was not significant at 5%. The lowest damage rating was recorded in DJ 6514, SSV 84, EC 19 x EP 133-2-3 and EC 12 X EP 133-5-2 (Table 7.2).

Plant stand per plot (1.2 m^2): The data on plant population per plot (2 rows of 2 m) was recorded at Parbhani, Solapur and Hyderabad. Across the genotypes and locations, the data on plant population was significant and ranged from 13.9 - 33.6 plants $plot^{-1}$ being an average of 25.2 plants $plot^{-1}$. The highest plant population was recorded in POP 52 (Table 7.3).

Day to (50%) flowering: Days to 50% flowering were recorded at Rahuri and Parbhani. Overall the range was varied from 77.7 – 89.3 d with an average of 83.1 days to flower at 50%. The entry EC 12 x POP 52-3-1 recorded earliest flowering 77.7 days, while PEC 1 recorded longest days (89.1 days) to flower (Table 7.3).

Overall resistant rating: The data on overall rating on resistance was recorded at Parbhani and Hyderabad. Across the locations and genotypes, the range was from 4.00- 6.00 with an average of 5.09. The entries recorded high resistant recovery (<5) are EC 12 x POP 52-3-1, EC 12 x EP 133-5-2, EC 19 x EP 133-2-3, EC 12, POP 52, LG Kumbhari, PEC 1, EC 19 and EC 15 (Table 7.3).

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 Parbhani, Hyderabad and Solapur. Overall, the range was106 to 237 g with a mean of 169 g plant $^{-5}$. The data was statistically significant at 5% level. Irrespective of locations and the genotypes, the higher grain yield was obtained in CSV 22 (237 g/ $plant^{-5}$) and the lowest was recorded in DJ 6514 (106 g) (Table 7.4).

Trial 8: Screening of Initial and Advanced lines for shoot fly resistance (IASFN) (Locations: 4)

In an Initial and Advanced Shoot fly Nursery (IASFN) trial, twenty lines from Rahuri, five from Parbhani and one from DSR were evaluated along with two resistant checks (IS 18551, IS 2205), one susceptible (DJ 6514) and one local check were evaluated for resistance to shoot fly at four locations: Dharwad, Rahuri, Parbhani and Solapur

Shoot fly (*Atherigona soccata,* Rond): Deadhearts caused by shoot fly at peak period were recorded at Rahuri, Parbhani, Solapur and Hyderabad. Across the locations and genotypes, the deadheart % range was from 34.2 to 77.6 % being an average of 45.3%. The data was statistically significant at 5%. The test entries that recorded lowest deadhearts (< 45%) are RSV 1003, NRCSFR09-3, RSV 1315, RSE 03, RSV 1410, RSV 1507, RSV 1635, RSV 1698, RSV 1683, RSV 1687, PBN-ENT-2, PBN-ENT-3 and PBN-ENT-4.These all test entries were on par with IS 18551 (Table 8.1).

Oviposition preference: The data on eggs laid on five plants at 14 DAE were recorded at Parbhani, Solapur and Hyderabad. Overall the data was not statistically significant at 5% level. Across the locations, the no of eggs on five plants was ranged from 2.61 to 9.56 eggs/5 pts with the average being 3.79 eggs. The test entries that recorded < 3 eggs are: RSV 1507, RSV 1687, and PBN-ENT-4 and were on par with IS 18551 (Table 8.1)

Spotted stem borer (*Chilo partellus,* Swinhoe) :The data on spotted stem borer infestation was assessed in terms of leaf injury rating (1-9), deadhearts (%) at 45 DAE, stem tunneling (%) and peduncle damage (%) at Parbhani and Hyderabad. Deadhearts caused by borer was recorded at Parbhani and Hyderabad. The range of deadhearts was from 5.48 – 16.22 % with an average of 8.31% deadhearts. Across the locations, the data was not significant at 5% and had high CV%. The lowest (<6%) deadhearts due to stem borer was recorded in RSV 1315 and RSV 1807 (Table 8.1). The data on Stem borer leaf injury rating (1-9) was recorded at Hyderabad. The damage ranged from 2.00 – 6.00 with an average of 3.46 in the scale of 1 to 9. The lowest leaf injury (< 3) was recorded in RSV 1003, NRCSFR09-3, RSV 1315, RSE 03, RSV 1507, RSV 1607, RSV 1698, RPASV 25, and Surthi were on par with resistant check IS 2205 (Table 8.1)

Morpho-physiological traits: Morpho-physiolgical traits such as seedling vigor and leaf glossiness have been recorded at Rahuri, Parbhani, Solapur and Hyderabad in the scale of 1-5. Across the locations, the data on leaf glossiness was significant at 5%. The highest glossiness was recorded in RSV 1315 and followed by RSSGV 46.

Across the locations the data on seedling vigor was not significant at 5%. The highest vigor was recorded in PBN-ENT-1 and followed by Surthi (Table 8.2).

Sugarcane aphid (*Melanaphis sacchari),* Zehntner: The data on sugarcane aphid damage on 1-9 scale was recorded at Parbhani. The damage ranged from 3.67 – 6.00 with an average of 5.08. The data was not significant at 5%. The lowest damage rating was recorded in RSV 1607 (3.67) (Table 8.2).

Head bug (*Calocoris angustatus):* The data on damage rating (1-9) due to head bug at milk stage was recorded at Parbhani only. The data was significant at 5% level. Across the genotypes, the data ranged from 3.33 to 5.00 averaging 4.07 damage rating. The lower damage rating (<3.5) was recorded in RSV 1003, RSV 1410, RSV 1507, RSV 1632 and RPASV 3 (Table 8.2).

Plant stand per plot (1.2 m^2): The data on plant population per plot (2 rows of 2 m) was recorded at Parbhani, Solapur and Hyderabad. Across the genotypes and locations, the data on plant population was significant and ranged from 23.8 - 35.6 plants $plot^{-1}$ being an average of 28.4 plants $plot^{-1}$. The highest plant population was recorded in RSV 1315 (Table 8.3).

Day to (50%) flowering: Days to 50% flowering were recorded at Rahuri and Parbhani. Overall the range was varied from 76.3 – 90.2 days with an average of 82.9 days to flower at 50%. the entry RSV 1410 recorded earliest flowering 76.3 days, while DJ 6514 recorded longest days (90.2 days) to flower (Table 8.3).

Overall resistant rating: The data on overall rating on resistance was recorded at Parbhani and Hyderabad. Across the locations and genotypes, the range was from 5.33 - 7.00 with an average of 6.29. None of the test entries recorded high resistant recovery. The test entry RSV 1698 (5.33) recorded relatively high recovery. However the data was not significant at 5% level (Table 8.3).

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 Parbhani, Hyderabad and Solapur. Overall, the range was 74 to 268 g with a mean of 174 g $plant^{-5}$. The data was not statistically significant at 5% level. Irrespective of locations and the genotypes, the higher grain yield was obtained in PBN-ENT-5 (268 g/ $plant^{-5}$) and the lowest was recorded in DJ 6514 (74 g) (Table 8.3).

Trial 9: Screening of B & R lines for shoot fly resistance (B & R lines-SF) (Locations: 4)

Total twenty four (5 SLBs, 10 SLRs, 4 SLVs) lines contributed by CRS, Solapur along with two resistant (IS 18551, IS 2205), one susceptible (DJ 6514), one local variety (CRS 11) and local check from respective locations were evaluated for resistance to major pests at four centers (Dharwad, Rahuri, Hyderabad and Solapur).

Shoot fly (*Atherigona soccata,* Rond): The data on shoot fly eggs on five plant at 14 DAE were recorded at Dharwad, Solapur and Hyderabad. Dharwad and Hyderabad had high CV% .The data at Dharwad was not significant at 5% level. Across the locations and genotypes the range of oviposition was from 2.22 to 5.22 with an average of 3.33 eggs/5 pts. The test entries SLR 84 and SLR 92 recorded relatively low oviposition (2.33 eggs/5 plants). However the data had high CV% (Table 9.1). The deadhearts percentage due to shoot fly at peak stage of infestation was recorded at Dharwad, Rahuri, Solapur and Hyderabad. At Dharwad, the entries that recorded <40 % DH are SLV 145, SLR 84, local check and SLR 143. At Rahuri, the entries that recorded <40%DH are SLR 70, SLR 72, SLV 91, SLV 145, SLR 84, SLR 93, SLR 75and local check. At Solapur, the range was from 28.1 to 70.3 with an average of 38.4%. The entries SLB 55, SLB 72, SLR 73, SLV 91, SLV 145 and SLV 93 recorded up to 33.7% deadhearts which were on par with resistant check IS 8551. At Hyderabad, the range was from 26.5 to 72.2% with an average of 38.8%. The entries SLB 72, SLR 70, SLV 71, SLR 72, SLR 73 and SLV 135 recorded up to 35.0% deadhearts which were on par with resistant check IS 8551. The data across the locations was significant at 5% level. The range was from 29.1 to 73.1% being an average of 42.5%. The entries that recorded lowest deadhearts % are SLB 72 & SLV 145 and on par with resistant check IS 18551 (Table 9.1).

Morpho-physiological traits: The data on morpho-physiolgical traits such as seedling vigor (1-5) and leaf glossiness (1-5) were recorded at Dharwad, Rahuri, Hyderabad and Solapur. Overall, the data on seedling vigor and glossiness was significant at 5% level. Across the locations and genotypes, the relatively lowest (< 2.5) rating on seedling vigor was recorded in SLR 84 and was on par with resistant check IS 2205, while the lowest (< 2.75) rating on glossiness was recorded in SLB 73, SLV 145a and SLR 93 and found equally good when compared to resistant check IS 2205 (Table 9.2).

Spotted stem borer (*Chilo partellus,* Swinhoe): The data on leaf injury rating (1-9) at 30 DAE and deadhearts due to stem borer at 45 DAE were recorded. The data on leaf injury rating recorded at Rahuri and Hyderabad. The data at Rahuri on leaf injury was non-significant and had high CV%. At Hyderabad, the data was significant at 5% level and ranged from 1.67 to 6.00 with an average of 3.76 in the scale of 1-9. The entries SLB 54, SLB 55, SLR 89 and SLV 145 recorded low leaf injury (< 3.0 and was at par with IS 2205 which is resistant check. Across the locations and genotypes, the data on leaf injury was non-significant at 5% level and had high CV%. The test entries SLR 54, SLR 55 and SLR 136 recorded relatively lowest leaf injury rating (2.77). The data on deadhearts % due stem borer at 45 DAE was recorded at Hyderabad only. Overall, the data varied from 3.5 to 23.8% being an average of 8.3%. The data was significant at 5% but had high CV%. The entries that showed relatively low deadhearts % (<5%) are SLR 72 and. SLB 84. Theses test entries are numerically on par with resistant check IS 2205 (Table 9.1).

Sugarcane aphid (*Melanaphis sacchari,* Zehntner): Sugarcane aphid plant damage rating (1-9) was recorded at Rahuri centre only. The damage rating caused due to sugarcane aphid was ranged from 3.67 to 6.33 with an average of 4.99. the entries SLV 135, DJ 6514, SLR 71, SLB 59 and SLB 55 recorded < 4.5 damage rating (Table 9.2).

Days to 50% flowering: The data on days to 50% flowering was recorded at Rahuri only. Overall range was varied from 75.7-93.3 days being an average of 81.7 days. Optimum flowering period was noticed in SLR 93 (82 days) followed by DJ 6514 (93.3 days). Whereas, SLB 72 and SLR 92 recorded early flowering (75.7 days) (Table 9.3).

Plant stand per plot (1.2 m^2): The data on plant population per plot (2 rows of 2 m) was recorded at Dharwad Hyderabad and Solapur. Across the locations and genotypes, the data on plant population was not significant. The mean plant population varied from 17.7 to 35.9 plants being an average of 25.2 plants $plot^{-1}$. The highest plant population was recorded in IS 2205 (Table 9.3).

Overall resistant rating: The data on overall rating on resistance was recorded at Hyderabad only. The range was varied from 3.00 - 7.33 with an average of 5.42. The data had high CV%. The test entries SLR 93, SLV 89, SLR 136 and SLR 84 recorded relatively high recovery (<4). The data however was significant at 5% level but had high CV% (Table 9.3).

Grain yield & its components: Grain yield on five plants was recorded at Hyderabad and Solapur. The range was varied from 47 to 207 g/5 plants with a mean of 141 g/5 pts. The data had high CV%. The test entry SLV 89 recorded highest yield (207 g) while DJ 6514 recorded lowest yield (43 g/5 pts) (Table 9.3)

Trial 10: Screening of Advanced Germplasm lines for shoot fly susceptibility (ANGSN-SF) (Locations 3)

A trial of thirty six test entries (34 germplasm lines, one resistant check IS 18551 and one susceptible check-DJ 6514) were selected from five hundred germplasm lines during Rabi 2012-13. These lines were evaluated for shoot fly resistant at two locations; Rahuri, Solapur and Hyderabad during Rabi 2013-14.

Shoot fly deadhearts at 28 DAE: The data recorded on shoot fly deadhearts at peak stage of infestation at three locations (Rahuri, Solapur and Hyderabad).. The data from all three locations were significant at 5% level. At Rahuri, the entries NSJB-6596, CJV 22, POP 39, POP 40, PEC 2, PEC 25, PU 6, EP 80, NSJB 6625, EP 96 and SEB 11988 had low deadhearts (< 35%) due to shoot fly and were on par with IS 18551. At Solapur, the entries EP 31, EP 82, NSJB 6596, CJV 11, CJV 22, POP 39, PEC 26, NSJB 6585, PU 8, PU 10, PU 15, PU 15, EG 7, EG 9, EG 20, EP 80 and NSJB 6625 were recorded low deadhearts (<35%) and was on par with resistant check IS 18551. At Hyderabad, the entries NSJB 6629, EA 11, CJV 22, EP 121, EG 24 and NSJB 6625 recorded low shoot fly damage (<36.6%) and were on par with resistant check. Overall, the data on shoot fly deadhearts at peak stage was varied from 26.6 to 71.2 % being an average of 39.6 %. The data was significant at 5% level Out of 36 entries, about 23 entries were on par with resistant check IS 18551. However the five germplasms that recorded below 36% are NSJB 6596, NSJB 6625, CJV 22, POP 39, & SEB 11988 (Table 10.1)

Oviposition preference: The data on eggs laid at 14 DAE per five plants were recorded at Solapur and Hyderabad. Overall the data was statistically significant at 5% level but had high CV%. Across the locations, the no of egg/5 plants were varied from 2.00 – 5.33 eggs with a mean of 2.94 eggs/5 pts. The test entries PEC 2, EP 80, NSJB 6585, PU 6, PU 15, POP 39 and NSJB 6629 recorded < 2.33 eggs/5 plants and was numerically equivalent to resistant check IS 18551 (Table 10.1).

Spotted stem borer (*Chilo partellus,* Swinhoe): The data on spotted stem borer infestation was assessed in terms of leaf injury rating (1-9) at Rahuri and Hyderabad and the data on deadhearts (%) at 45 DAE was recorded at Hyderabad only. The range of deadhearts was from 3.5 - 17.2 % with an average of 8.1% deadhearts. The data was significant at 5% but had high CV%. The lowest (<5%) deadhearts due to stem borer was recorded in PEC 2, EP 100, CJV 11, POP 45, NSJB 6585 and ELG 4 (Table 10.2). The leaf injury rating was varied from 1.67 – 4.00 with an average of 2.60 in the scale of 1 to 9. The lowest leaf injury (< 2) was recorded in EP 121, POP 39, POP 40 and IS 18551. However, the data was not significant at 5% level (Table 10.2)

Sugarcane aphid (*Melanaphis sacchari),* Zehntner: The plant damage due to sugarcane aphid was assessed in terms of damage rating (1-9 scale) and recorded at Rahuri. The damage rating varied from 3.0 to 4.67 with an average of 3.81. However, the data was not significant at 5% level. The lowest damage was recorded in EP 80, EG 26, EG 24 and NSJB 6629 (Table 10.2)

Morpho-physiological traits: The data on morpho-physiolgical traits such as seedling vigor and leaf glossiness in the scale of 1-5 were recorded at Rahuri, Solapur and Hyderabad. Overall the lowest rating (< 2.22) on seedling vigor was recorded in EP 31, SEVS 12, EG 9, EG 26 and IS 18551. The lowest glossiness (< 2.44) was recorded in IS 18551, CJV 22, NSJB 6596 and EP 82 (Table 10.2).

Day to (50%) flowering: Days to 50% flowering were recorded at Rahuri. The range was varied from 74.0 to 89.7 with an average of 81.3 days. PEC 26 recorded longest period (81.3 days) to complete flowering at 50% while EG 26 took least days (74 days) to flower (Table 10.2).

Plant stand per plot (1.2 m^2): The data on plant population per plot (2 rows of 2 m) was recorded at Solapur, and Hyderabad. Across the locations, the data on plant population was significant and varied from 13.0-39.7 plants being an average of 29.8 plants $plot^{-1}$. The highest plant stand was recorded in EP 100 (Table 10.2).

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 Hyderabad and Solapur. Overall, the range was 50 to 210 g with a mean of 119 g $plant^{-5}$. The data was statistically significant at 5% level. Irrespective of locations and the genotypes, the higher grain yield was obtained in PU 10 (210 g/ $plant^{-5}$) and the lowest was recorded in EG 9 (50 g/ $plant^{-5}$) (Table 10.2).

Trial 11: Evaluation of elite material for sugarcane aphids and shoot bug resistance (APSHN-DSR) (Loc: Bijapur, Rahuri, Parbhani, Hyderabad & Solapur)

The trial comprising thirty entries were subjected to evaluation for aphids and shoot bug resistance during Rabi 2013-14. The trials were conducted at five test locations (Rahuri, Bijapur, Solapur, Parbhani, and Hyderabad. All entries were evaluated under artificial condition and plants were inoculated with aphids (leaf tagging method). 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 population/sqcm/leaf, aphid damage rating (1-9), days to flowering (50%), plant height (cm) at maturity, SPAD reading and grain yield (g) on 2 plants. The genotypes 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 colonization of sugarcane aphids (no of aphids/cm^2/leaf) at milky stage was recorded at Solapur and Hyderabad and Parbhani. At Solapur, the range was varied from 23.1 to 116.0 aphids with an average of 76.3 aphids/cm^2/leaf. The data was significant at 5% level but had high CV%. The lowest aphid population (<70 aphids/cm^2/leaf) was recorded in SLR 31, SLB 83, KR 191, KR 196, local check, C 43 and Hathi kuntha and was equally comparable with resistant check TAM 428. The susceptible check B 35 recorded 103 aphids/cm^2/leaf. At Hyderabad, the aphid population was varied from 24.9 to 94.4 aphids/cm^2/leaf with an average of 40.6 aphids. The data was significant at 5% level. At Hyderabad, the lowest aphid population (<30 aphids/cm^2/leaf) was recorded in SLB 64, SLB 77, ICSV 745, IS 2205, local check and KR 191 and was equally comparable with resistant check TAM 428. At Parbhani, the range was varied from 8.7 to 34.3 aphids/cm^2/leaf with an average of 23.4 aphids/cm^2/leaf. The data was significant at 5% level. The lowest aphid population (<15 aphids/cm^2/leaf) was recorded in C 43, KR 191 and KR 196 and was equally comparable with resistant check TAM 428. Across the locations and the genotypes, the data on aphid population was significant at 5% level but had high CV%. The data varied from 20.7 to 76.0 with an average of 46.6 aphids/cm^2/leaf. The lowest aphid population (< 45 aphids/cm^2/leaf) was recorded in SLB 77, SLB 80, SLB 81, SLB 83, SLR 31, C 43, KR 191, KR 196 and Long SPS 43 and did not differ from the resistant check TAM 428 (Table 11.1).

The plant damage due to aphids was assessed in scale of 1-9 and was recorded at five locations (Bijapur, Rahuri, Parbhani, Hyderabad and Solapur). At Bijapur, the aphid damage rating was varied from 5.33 to 8.33 with a mean of 6.70. The entries that recorded damage up to 6 rating are SLB 79, SLB 83, SLR 31, IS 2205, C 43, KR 191, KR 196 and CSV 18R. At Rahuri, the damage range was from 2.33 to 7.67 with an average of 3.83. The entries that recorded damage up to 3 rating are SLB 64, SLB 83, ICSV 93046 and SLR 37. At Solapur, the damage rating range was varied from2.00 to 8.33 with an average of 6.38. The entries that recorded damage up to 5 are SLR 31, C 43, KR 191 and KR 196. At Hyderabad, the damage range was varied from 2.33 to 6.67 with an average of 3.83. The entries recorded lowest (< 3) damage rating are SLB 19, SLB 64, SLB 50, SLB 77, SLB 80, SLR 31, ICSV 745, IS 2205, KR 191 and SLR 37. At Parbhani, the range was from 2.00 to 7.00 with an average of 5.29 damage rating. The entries C 43, KR 191, KR 196 and TAM 428 recorded least damage rating (2.00). Across the locations and genotypes the range of damage rating was varied from 3.13 to 6.73 being an average rating of 5.21. The data was significant at 5% level. The entries that recorded damage up to 5 rating are SLB 64, SLB 77, SLB 79, SLB 80, SLB 83, SLR 31, KR 191 and KR 196 and were par with resistant check TAM 428. The susceptible check B 35 recorded 6.75 damage rating (Table 11.1).

Shoot bug (Peregrinus maidis, Ashmead): The data on shoot bug population/plant was recorded at Bijapur. The data was non-significant and had high CV%. The populations varied from 14.0 to 33.7 with an average of 22.3 shoot bugs plant $^{-1}$. The entries Y 75, Hathi kuntha, IS 2205, B 35 and SLB 19 recorded up to 18.5 shoot bugs plant $^{-1}$. The entry SLB 77 recorded highest bugs 33 shoot bugs plant $^{-1}$. The data on plant damage rating (1-9) was recorded at Bijapur only. The data was non-significant and had high CV%. Overall very low damage rating was recorded. It was varied from 1.00 to 2.67 in the scale of 1-9 with an average rating of 1.76. No significant differences amongst the genotypes were observed. However, the entries SLB 19, CRS 11, Y 75, IS 2205 and B 35 recorded very low damage (1.0) Highest damage rating was recorded in SLB 77 (Table 11.1).

SPAD reading: The data SPAD was recorded at Parbhani, Bijapur, Solapur and Hyderabad Solapur to know the variation of chlorophyll content in different genotypes and further to get information on correlations with biotic factors. Across the locations and genotypes the SPAD value varied from 43.1- 53.0 with an average of 48.3. The highest SPAD was recorded in CSV 18R, and lowest in SLR 31 (Table 11.1).

Morpho-physiological traits: Morpho-physiolgical traits such as seedling vigor and leaf glossiness have been recorded at Bijapur, Rahuri and Parbhani. The data on seedling vigor rating (1-5) was recorded from 2.6 to 3.4 with an average of 2.9. The data was non-significant at 5% level. The range of glossiness rating (1-5) was from 2.39 to 3.39 with an average of 2.98 (Table 11.2).

Days to (50%) flowering: Days to 50 % flowering was recorded at Rahuri and Solapur. Across the locations, the flowering range was 69 to 88 days with an average of 76 days. The data was significant at 5 % level. The entries SLB 83, IS 2205, KR 191 and CSV 18R recorded longer flowering (>80 days) and found significant. The entries TAM 428 recorded shortest duration of flowering (69 days) (Table 11.3).

Plant height (cm): Plant height (cm) was recorded at Rahuri, Parbhani and Solapur centre. Across the locations, it showed that CSV 18R recorded 205 cm plant height and TAM 428 recorded 81 cm height. The data was significant at 5 % level (Table 11.3).

Grain yield (g) per five plants: The grain yield (g/5plants) was recorded at Solapur and Hyderabad. The range was varied from 95 to 218 g with an average of 152 g/5plants. CSV 18R recorded highest grain yield (288 g). The data was significant at % % level (Table 11.3).

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

Trial 12: Evaluation of organic components for shoot pests management in sorghum (Locations: Bijapur & Tandur)

Bijapur: At Bijapur center integrated management of sorghum pests was attempted during Rabi 2013-14 comprising use of organic manures (Vermicompost and Neem cake). There were seven treatments viz., T_1- Application of Vermicompost @ 7.5 q/ha; T_2 - Application of oiled Neem cake @ 6.25 q/ha; T_3- Application of Vermicompost (50%) + oiled Neem cake (50%) @ 3.75 + 3.12q/ha; T_4 - Application of Vermicompost @ 7.5 q/ha + 50% RDF; T_5 - Application of oiled Neem cake @ 6.25 q/ha + 50 % RDF; T_6 - 100 % RDF; T_7 - Untreated check. Incidence of shoot fly, aphids and shoot bug was recorded. *Shoot fly*: The shoot fly incidence at 28 DAE was recorded. The mean shoot fly incidence in trial was 20.11 % deadhearts. There was significant difference among the treatments. The application of Application of oiled Neem cake @ 6.25 q/ha recorded lowest shot fly

damage (17.6%). The data of shoot fly deadhearts% was on par with application of oiled Neem cake @ 6.25 q/ha + 50% RD, Vermicompost @ 7.5 q/ha + 50% RDF and Vermicompost @ 7.5 q/ha + 50% RDF. Control recorded highest shoot fly deadhearts 25.8%. ***Aphids:*** The aphid infestation was quantified in terms of aphids/cm^2 of leaf. The mean aphid population was 55.19 aphids/ cm^2. There were significant differences among the treatments. The application of Vermicompost (50%) + oiled neem cake (50%) @ 3.35+ 3.12 q/ha and application of Vermicompost @ 7.5 q/ha + 50% RDF recorded lowest aphid population (<38 aphids/ cm^2). The highest aphid numbers was recorded in 100 % (80.8 aphids/ / cm^2). RDF7.5 q/ha recorded 51.6 % reduction in aphid incidence followed by application of 100 % RDF. ***Shoot bug***: The shoot bug was quantified in terms of population/ plant. The mean shoot bugs population was 56.30 shoot bugs/plant in trial was 24.7 no./plant. There were significant differences among the treatments. The lowest shoot bug populations was recorded in the treatment of Application of Vermicompost (50%) + oiled Neem cake (50%) @ 3.75 + 3.12q/ha and was found superior to the rest of the treatments. The highest population of bugs was recorded in control (Table 12.1). ***Fodder yield***: There was no significant difference. between treatments. However, the application of Vermicompost @ 7.5 q/ha + 50% RDF recorded highest fodder yield 3.33 q/ha. ***Grain yield:*** The application of Vermicompost (50%) + oiled Neem cake (50%) @ 3.75 + 3.12q/ha recorded highest yield (24.47 q/ha) followed by the application of Vermicompost @ 7.5 q/ha + 50% RDF recorded 23.50 q/ha (Table 12.1).

Table 12.1: Evaluation of eco-friendly approaches for management of shoot pest in sorghum Rabi 2013-14 at RARS, Bijapur

Treatments -7; Gross plot size: 3.6 x 5.0 m = 18 sq m; Net plot size: 2.4 x 4.7 m = 11.28 sq m

Sl. No.	Treatment	SFDH%	Aphids l/cm ^{2}	Shoot bug/plant	Fodder yield (q/ha)	Grain yield (q/ha)
T_1	Application of Vermicompost @ 7.5 q/ha	17.6	44.5	46.8	2.47	21.43
T_2	Application of oiled Neem cake @ 6.25 q/ha	16.8	44.7	48.9	2.57	22.10
T_3	Application of Vermicompost(50%) + oiled Neem cake(50%) @ 3.75 + 3.12q/ha	22.0	37.6	37.3	3.20	24.47
T_4	Application of Vermicompost @ 7.5 q/ha + 50% RDF	17.5	37.9	56.1	3.33	23.50
T_5	Application of oiled Neem cake @ 6.25 q/ha + 50 % RDF	17.1	60.8	54.6	3.13	23.10
T_6	100 % RDF	24.0	80.8	73.7	2.63	21.27
T_7	Untreated check	25.8	80.0	76.8	2.07	18.80
	Mean	20.11	55.19	56.30	2.77	22.11
	CD (0.05)	4.53	2.31	2.45	7.31	5.13
	CV (%)	1.62	2.26	2.44	3.36	2.03

Tandur: At ARS, Tandur center Integrated management of sorghum pests was attempted during Rabi 2013-14 comprising of use of organic manure (Vermicompost) There were seven treatments viz., T_1- Application of vermicompost @ 7.5 q/ha (1.35 kg/18m2); T_2 - Application of deoiled neem cake @ 6.25 q/ha (1.125 kg/18m2); T_3- Application of vermicompost (3.75 q/ha) + deoiled neem cake (3.12 q/ha); T_4 - Application of vermicompost @ 7.5 q/ha (1.35 kg/18m2) + 50% RDF; T_5 - Application of deoiled neem cake @ 6.25 q/ha (1.125 kg/18m2) + 50 % RDF; T_6 - 100 % RDF; T_7 - Control. Incidence of shoot fly, aphids and shoot bug was recorded. ***Shoot fly***: The shoot fly incidence at 28 DAE was recorded. The mean shoot fly incidence in trial was 24.12 % deadhearts. There was significant difference among the treatments. Application of Vermicompost @ 7.5q/ha+ 50% RDF recorded 15.7% deadhearts due to shoot fly at 28 DAE and followed by the Application of deoiled neem cake @ 6.25q/ha+ 50% RDF (17.7%). ***Stem Borer:*** The data were recorded on deadhearts (%) and peduncle damage (%) due to stem borer. Application of Vermicompost @ 7.5q/ha+ 50% RDF recorded low deadhaerst and peduncle damage % as compared to other treatments. ***Aphids:*** The aphid infestation was quantified in terms of aphids/cm^2 of leaf. The mean aphid population was 18.99 aphids/ cm^2. All treatment were on par except control. Application of Vermicompost (50 %)+ Application of deoiled neem cake(50 %) @ 3.75q/ha+3.12 q/ha and Application of Vermicompost @ 7.5q/ha+ 50% RDF recorded 16.66 aphids/leaf. ***Fodder yield***: There was no significant differences between treatments. The application 100% RDF recorded highest fodder yield (40.0 q/ha).

Grain yield: Application of deoiled neem cake @ 6.25q/ha+ 50% RDF recorded highest yield (27.33 q/ha) followed by Application of Vermicompost @ 7.5q/ha+ 50% RDF 26.00 q/ha (Table 12.2).

Table 12.2: Management of shoot pests in sorghum through eco friendly and cost effective approach at ARS-Tandur-Rabi 2013

Treatment 7; Gross plot size: 3.6 x 5.0 m = 18 sq m ; Net plot size: 2.4 x 4.7 m = 11.28 sq m

S. No.	Treatment	SF DH % (28DAE)	SB DH % (45DAE)	PDP (%) (At harvest)	HB POP/P (at milk stage)	Fodder yield (q/ha)	Grain Yield (q/ha)
T_1	Application of Vermicompost @ 7.5q/ha	23.64 (29.07)	12.13 (20.35)	6.69 (14.97)	18.66 (4.43)	36.00	23.83
T_2	Application of deoiled neem cake @ 6.25q/ha	25.78 (30.49)	12.37 (20.58)	7.82 (16.23)	17.33 (4.28)	35.33	23.50
T_3	Application of Vermicompost (50 %)+ Application of deoiled neem cake(50 %) @ 3.75q/ha+3.12 q/ha	22.65 (28.36)	11.89 (20.15)	8.96 (17.39)	16.66 (4.20)	38.66	25.00
T_4	Application of Vermicompost @ 7.5q/ha+ 50% RDF	15.69 (23.31)	8.12 (16.54)	5.66 (13.76)	16.66 (4.18)	37.33	26.00
T_5	Application of deoiled neem cake @ 6.25q/ha+ 50% RDF	17.73 (24.89)	8.61 (17.05)	5.67 (13.76)	18.66 (4.43)	39.33	27.33
T_6	100% RDF	24.17 (29.42)	10.27 (18.67)	6.84 (15.15)	19.33 (4.50)	40.00	24.87
T_7	Control	39.18 (38.67)	17.43 (24.65)	14.03 (21.98)	25.66 (5.15)	34.66	20.67
	Mean	24.12 (29.42)	11.55 (19.71)	7.95 (16.18)	18.99 (4.45)	37.33	24.46
	CD (5%)	3.33	1.88	1.35	0.50	2.24	1.42
	CV (%)	6.34	5.32	4.64	6.31	3.34	3.21

Conclusions: In the Integrated pest management trials conducted at two locations: Bijapur and Tandur. Application of Vermicompost (50 %)+ Application of deoiled neem cake or oilneem cake along with (50 %) dose of RDF or application of Vermicompost @ 7.5q/ha+ 50% RDF found better treatment for management of pests and good returns.

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Annexure I: List of collaborators from AICSIP centre

No	Name	Brief address	email
1	Dr. P Anandhi Sorghum Entomologist	ARS, TNAU, Kovilpatti- 628 501, Tamil Nadu.	kovilpatti@sorghum.res.in
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Annexure II: Entomology trials data-Compliance report

S No	Centre	No of trials supplied	Sowing	Date of data received					
				Shoot fly	Stem borer	Shoot bug	Head bug	Aphids	Midge
1	Kovilpatti	6	17 Oct	R	R	X	R	X	X
2	Bijapur	8	18 Oct	R	X	R	R	R	X
3	Dharwad	7	26 Sep	R	X	X	X	X	X
4	Tandur	6	28 Sep	R	R	X	X	R	X
5	Rahuri	12	10 Oct	R	R	X	R	R	X
6	Parbhani	9	30 Sep	R	R	X	X	R	X
7	Solapur	11	30 Sep	R	X	X	X	R	X
8	Hyderabad			X	R	X	X	R	X

X = Not Recorded; R= Received

Annexure III: Hot spots locations for key pests

Centre (Hot spot)	Key peats
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 IV: Summary of trials allotted to AICSIP

PI: VR Bhagwat Discipline: Entomology

Trl No	Name of Trial	Entries x Rep	Row x row length	Centers								
				Kovi	Bija	Dhar	Tand	Rahu	Parb	Sola	Hyd	Total
1	AVHT-DS	20 x 3	2 x 2	1	1	1	1	1	1	1		7
2	IHT-SS	18 x 3	2 x 2	1	1	1	1	1	1	1		7
3	IVT-DS	27 x 3	2 x 2	1	1	1	1	1	1	1		7
4	IVHT-SS	22 x 3	2 x 2	1	1	1	1	1	1	1		7
5	AICSIP-DS-SPN	20 x 3	2 x 2	1	1	1	1	1	1	1		7
6	AICSIP-SS-SPN	16 x 3	2 x 2	1	1	1	1	1	1	1		7
7	SFR (F_8) lines	20 x 3	2 x 2					1	1	1	1	4
8	IASFN	30 x 3	2 x 2					1	1	1	1	4
9	B& R lines-SF	24 x 3	2 x 2			1		1		1	1	4
10	Advanced lines-NGSN	36 x 3	2 x 2					1		1	1	3
	Aphid and shoot bug Nursery (APSHN)	30 x 3	2 x 2		1			1	1	1	1	5
11	IPM/organic	7 x 3	18 x 7		1							1
12	Pest survey			1	1	1	1	1	1			6
	Total	263		**7**	**9**	**8**	**7**	**12**	**10**	**11**	**5**	**69**

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

Pest	Crop age (days)	Resistance parameters
Shoot fly	14 & 21	No. of eggs / 5 seedlings
	At peak stage	Deadhearts (%)
Stem borer	30 & 45	Leaf feeding score (1-9) (1= low ; 9 = high)
	45	Deadheart (%)
	At harvest	Peduncle damage (%)
Sugarcane aphid	60	Plant damage rating (1-9) (1= low; 9 = high) (Based on necrosis/sooty molds)
Shoot bug	60 or 75	Plant damage rating (1-9) (1= low; 9 = high)
Sorghum midge	At milk stage	Plant damage rating (1-9) (1= low; 9 = high)
Ear head bug	At milky stage	Head bug population/plant
	At milky stage	Head panicle damage rating 1-9) (1= low; 9 = high
Grain Yield	After harvest	Grain yield/5plants (g)