

Sorghum entomology - Rabi 2011-12

Contents

Executive summary	2
Detailed report	4
I. Pest survey & surveillance & seasonal abundance (7 locations)	4
II. Evaluation of grain sorghum experimental varieties and hybrids for resistance to key pests on different type of soils	5
<i>Trial 1: Advance Varietal and Hybrid Trial for deep soil (AHVT-DS) (Loc: All centers)</i>	5
<i>Trial 2: Advanced Varietal & Hybrid Trial for shallow soil (AVHT-SS) (Loc: All centers)</i>	7
<i>Trial 3: Initial Varietal and Hybrid Trial for deep soil (IVHT-DS) (Loc: All centers)</i>	9
<i>Trial 4: Initial Varietal and Hybrid Trial for shallow soil (IVHT-SS) (Loc: All centers)</i>	11
III. Screening of initial and advance material for specific pest resistant	12
<i>Trial 5: SFR materials from Germplasm for shoot fly resistance (SFR-F5-SF) (Loc: Hyderabad, Rahuri and Parbhani)</i>	12
<i>Trial 6: Evaluation of local checks of different centers shoot fly and stem borer resistance (LC-SF&SB) (Loc: Kovilpatti, Bijapur, Dharwad and Solapur)</i>	14
<i>Trial 7: Screening of B& R lines for shoot fly resistance (B&R lines-SF) (Loc: Dharwad, Rahuri and Solapur)</i>	15
<i>Trial 8: Screening of advanced lines for shoot fly resistance (ASFN) (Loc: Dharwad, Rahuri Parbhani and Solapur)</i>	16
<i>Trial 9: Evaluation of elite material for sugarcane aphids and shoot bug resistance (APSHN) (Loc: Bijapur, Rahuri, Parbhani and Solapur)</i>	17
IV. Screening of initial and advance material for shoot fly and aphids resistance	18
<i>Trial 10: Screening of advanced lines for shoot fly resistance under diversified conditions (Loc: Solapur). ICAR-ICRISAT collaborations</i>	18
<i>Trial 11: Evaluation for Sugarcane Aphid resistance (APH) (Loc: Solapur) ICAR-ICRISAT collaboration</i>	18
<i>Trial 12: Screening of Germplasm lines for stem borer susceptibility (NGSN-SF)</i>	19
V. Management of shoot pests in sorghum through eco-friendly and cost effective approach	20
<i>Trial 13: Validation of IPM modules for shoot pests in sorghum at Kovilpatti</i>	20
<i>Trial 14: Testing of organic IPM modules for shoot pests in sorghum at Bijapur</i>	21
<i>Trial 15: Testing of IPM module on farmer's field in sorghum at Parbhani</i>	22
<i>Annexure-I: List of collaborators from AICSIP centre</i>	23
<i>Annexure-II: Entomology trials data-Compliance report</i>	23
<i>Annexure-III: Summary of trials allotted to AICSIP</i>	24
<i>Annexure-IV: Parameters for insect pest resistance used for recording observations</i>	24
<i>Annexure-V: Hot spots locations for key pests</i>	24

Executive summary

Introduction: Genotypes from nine trials (AVHT-DS, AVHT-SS, IVHT-DS, IVHT-SS, SFR (F5), Local checks, B & R lines, ASFN and Aphids Nursery trials) were evaluated mainly for shoot fly, stem borer, sugarcane aphids and shoot bugs for resistance/tolerance at the hot -pot locations : Kovilpatti, Dharwad, Bijapur, Rahuri, Parbhani, Tandur, Hyderabad and Solapur. In most of the parts there were inadequate rains during Kharif as a results Rabi crop suffered due to residual moisture that influenced on the later part of plant growth during maturity.

Pest scenario in sorghum: In Rabi sorghum, shoot fly (*Atherigona soccata* Rond.) is a major biotic constraint followed by the sugarcane aphid (*Melanaphis sacchari* Zehntner), and corn plant hopper (shoot bug) (*Peregrinus maidis* Ashm.). They often occur sequentially or together. 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. The stem borer (*Chilo partellus* Swin.) occasionally occurs but not considered as severe pest in Rabi sorghum.

In Kovilpatti region there was low damages due to shoot fly (0.0-10.45 %) and stem borer (18-20%). Midge incidence was moderate but low on K-8. Low population of head bug and shoot bug were noticed. In Karnataka, The incidence of shoot fly ranged from 25- 60 % The populations of stem borer, head bug, shoot bug, aphids, ear head caterpillar's viz., *Helicoverpa armigera*, *Stenochroia elongella* and were negligible during the cropping season. *Coccinellids* were observed in the month of January in some of farmer's field. Shoot bug damage was recorded in Bijapur area and was about 38%. Aphid damage was recorded up to 60%. In Maharashtra, overall shoot fly damage was moderate to high (up to 40%). The incidence of stem borer was very low (< 3 %), particularly, peduncle damage was recorded up to 10%.

Shoot fly (*Atherigona soccata*, Rond)

General trend: The shoot fly incidence was moderate to high (15-90%) at Dharwad, Parbhani, Rahuri and Solapur when evaluated under artificial conditions.

Advanced varietal & hybrids (DS & SS): In AVHT-DS, AVHT-SS trials, very few of the test entries (SPV 2034, SPV 2049, P. Anuradha, SPV 2034, SPV 204, SPV 2029, Maulee, SPV 2038, SPV 2031) found better than resistant check IS 2312 or IS 18551. The range was of deadhearts at 28 DAE was from 20 to .70%.

Initial varietal & hybrids (DS & SS): In IVHT-DS & IVHT –SS trials SPV 2141, SPV 2139, SPV 2152, SPV 2138 and SPV 2143, SPV 2160 and P. Anuradha recorded notable low damage due to shoot fly.

Germplasm, Shoot fly resistant nursery trials: Elite lines and preliminary lines were evaluated at hot spot places. The promising ones are EC 12 x EP 133-5-2, EC 12 x POP 52-3-1, EC 19 x EP 133-2-3, PEC 9 and LG Kumbhari local and NRCSFPR09-3, NRCSFPR10-4, RSE 03 and M 35 x RR 9808. From genetic stock evaluation, the lines SEVS –12, EP –80, E – 8, E –92, E –97, PEC –5, PEC –8, NSJB-6562, EG –57, SEB –12002, SEB –12008 and EG -97 had recorded lowest damage (up to 30%).

Overall conclusions: The 3 years data of shoot fly revealed that Dharwad, Parbhani, Rahuri centre may be considered for hot spot for shoot fly screening, further thee is a need to record the data on plant height, days to flowering, effective tillering to interpret the findings in a more effective way.

Spotted stem borer (*Chilo partellus*, Swinhoe)

General trend: The stem borer incidence was moderate. The highest damage was noticed at Palem (~20 %). At Kovilpatti, Parbhani moderate population was observed mostly peduncle damage was seen.

Advanced varietal & hybrids (DS & SS): The overall mean of DH % due to stem borer at 45 DAE was 8.00 %. The test entry SPV 2034, SPH 1690, Local check, C 43 and Y 75, Local check, SPV 2029, SPV 2031, CSH 15R recorded at 45 DAE and the range was from 0.0 -40.0 %. All test entries were on par with resistant check IS 2205.

Initial varietal & hybrids (DS & SS): Across the locations and zones the overall mean DH % due to stem borer at 45 DAE was 10.0% and the range was from 0.00- 15.00 %. The entry SPV 2157, SPV 2161, SPV 2152 and was on par with resistant check IS 2312.

Overall conclusions: Moderate to high incidence of stem borer. However, there is a need to develop and identify improved resistance sources for stem borer. The peduncle damage needs to be studied at Parbhani and Kovilpatti.

Head bug (*Calocoris angustatus*): Head bug population density and damage rating at milk stage was recorded at Kovilpatti. The population colonization of head bugs was up to 30 bugs/panicle. The entries that showed promises in AVHT trials are: SPH 1663, CSH 15R, Local check, TAM 428, M 35-1, CSH 15R, C 43 and Y 75.

Sugarcane aphids (*Rhopalosiphum maidis*): The data on aphid damage rating (1-9) was recorded at Bijapur, Rahuri and Parbhani centers. The range was from 4.5-8.0 with an average of 6.5 damage rating. The damage rating was low in SPVs 2033, 2035, 2049, 2031, 2034, SPH 1690 in advanced trials. The entries SLB 50, SLB 79, SLB 80, SLB 83, ICSV 93046, KR 191, KR 196, ICSB 323, 61588, ICSB 323, ICSR 165, RS 29, LONG SPS 43 and TAM 428 found promising in aphid resistant nursery trials.

Shoot bug (*Peregrines maidis*, Ashmead): The shoot bug damage rating was observed from 1.5 to 4.5 with an average of 3.5. the entries SPH 1666, SPV 2034, SPV 2035, SPV 2049, SPH 1689, P. Anuradha, Y 75, CSH 15R, LC, SPV 2031 had low shoot bug damage in advanced trials. Whereas, in aphid & shoot bug nursery trials the entries ICSV 93046, SLB 50, SLB 81 and M-35-1 showed low damage.

Validation of IPM: Validation of IPM modules was studied at two locations: Kovilpatti and Bijapur. The seed treated sorghum (either with Imidacloprid @ 5 g/kg seed or Thiamethoxam 70 WS @ 3 g/kg seed) and plus spraying of metasystox (0.07%) or NSKE (5%) was beneficial in terms of reducing pest damage and producing higher yield as compared to other treatments. On farm trial at Parbhani was benefited to the farmers in terms of grain and fodder yield as compared to regular control.

Looking ahead: There is a need to repetition of conducting large scale trials on IPM at farmer's field through front line demonstrations.

Future work plan Rabi 2011-12:

- Germplasm may be evaluated at hot spot locations to identify improved sources for major pests.
- **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, Dharwad, 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 may not occur regularly, but occasionally Dharwad, Kovilpatti and may be considered as testing spots.
- **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.

Table 1: Promising entries with less susceptibility to key pests of grain sorghum in different AICSIP trials- Rabi 2011-12 (Locations: 7)

Trial	Shoot fly	Stem borer	S. aphids	Shoot bug	H bug
AVHT-DS	SPV 2034 and SPV 2049	SPV 2034, SPH 1690, Local check, C 43 and Y 75	SPV 2033, SPV 2035, SPV 2049, SPH 1690, M-35-1	SPH 1666, SPV 2034, SPV 2035, SPV 2049 and SPH 1689	SPH 1663, CSH 15R, Local check and TAM 428
AVHT-SS	Phule Anuradha, SPV 2034, SPV 204, SPV 2029, Mauli, SPV 2038, SPV 2031 and Local check	Local check, SPV 2029, SPV 2031, CSH 15R	Local check, SPV 2031 and SPV 2034	Phule Anuradha, Y 75, CSH 15 R, Local check, SPV 2031	M 35-1, CSH 15R, C 43 and Y 75
IVHT-DS	SPV 2141, SPV 2139, SPV 2152, SPV 2138 and SPV 2143	SPV 2152	CSH 15R, SPV 2144, SPV 2154, SPV 2153, SPH 1720, SPV 2145, SPV 2142, CVS 22, SPV 2139	Local check, SPV 2151, SPH 1721, SPV 2146, CSH 15R and SPV 2150	SPV 2139, SPV 2140 and SPV 2154
IVHT-SS	SPV 2160, Phule Anuradha	SPV 2157, SPV 2161	SPV 2163, SPV 2161, CSH15R, TAM 428	C 43, SPV 2161, SPV 2160, SPV 2162 and Maulee	SPV 2157, SPV 2163, CSH 15R, M-35-1, TAM 428 and DJ 6514
SFR (F ₅)-SF	Shoot fly: EC 12 x EP 133-5-2, EC 12 x POP 52-3-1, EC 19 x EP 133-2-3, PEC 9 and LG Kumbhari local				
LC-SF-SB	Local checks, DSV 4, DSV 5, CSV 22, Phule Anuradha and M 35-1	DSV 4, CSV 216R, Maulee	Parbhani Moti, K-8 and M-35-	Parbhani Moti, K-8 and M-35-	
B & R lines	SLB 50 and SLB 25-1	SLB 50, SLB 56, SLB 59, SLB 71, SLB 72, SLR 72 and SLR 73	SLR 73		
ASFN	Shoot fly: NRCSFPR09-3, NRCSFPR10-4, RSE 03 and M 35 x RR 9808				
APSHN	Aphids: SLB 50, SLB 79, SLB 80, SLB 83, ICSV 93046, KR 191, KR 196 and long SPS 43			Shoot bug: ICSV 93046, SLB 50, SLB 81 and M-35-1	
SFR (ICAR-ICRISAT)	Shoot fly: 32733, ICSB 424, ICSB 433, ICSB 463, ICSB 708, ICSB 717, ICSV 93093, IS 5480, IS 5622 and PS 35805				
APHN (ICAR-ICRISAT)	Aphids: ICSB 323, 61588, ICSB 323, ICSR 165, RS 29, LONG SPS 43 and TAM 428				

Detailed report

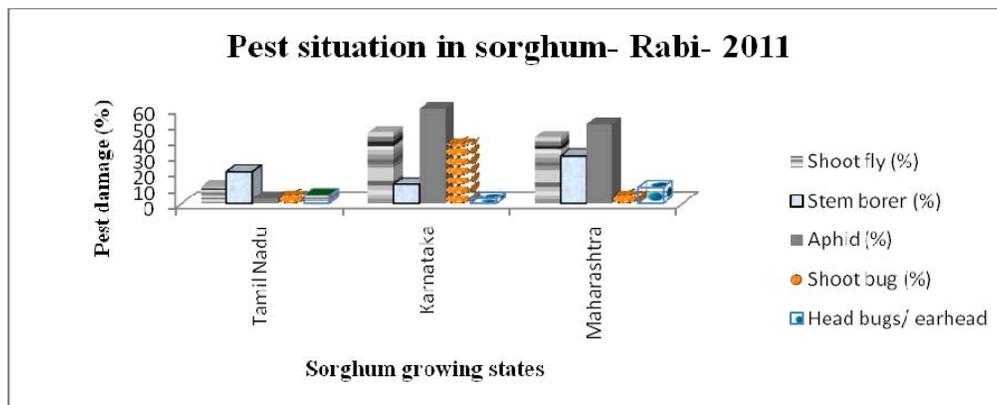
I. Pest survey & surveillance & seasonal abundance (7 locations)

In Rabi sorghum, shoot fly (*Atherigona soccata* Rond.) is a major biotic constraint followed by the sugarcane aphid (*Melanaphis sacchari* Zehntner), and corn plant hopper (shoot bug) (*Peregrinus maidis* Ashm.). They often occur sequentially or together. 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. The stem borer (*Chilo partellus* Swin.) occasionally occurs but not considered as severe pest in Rabi sorghum.

Tamil Nadu: 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 2011. The data showed that there was low damage due to shoot fly (0.0-10.45 %) and stem borer was up to 18-20 %. The leaf damage due to stem borer was moderate (15%). The population of ear head caterpillar was up to 2 larvae per ear head and the damage rating was 1 to 3. Midge incidence was moderate but low on K-8. Low population of head bug and shoot bug were noticed. Midge spikelet damage % was 0.00 to 21.09 and head bug panicle damage rating was 3 in the scale of 1-9.

Karnataka: In Dharwad region, the key pests observed during the survey were shoot fly, stem borer and aphids. The incidence of shoot fly ranged from 25.50 to 60.34 % with mean of 28% dead heart. The populations of stem borer, head bug, shoot bug, aphids, ear head caterpillar's viz., *Helicoverpa armigera*, *Stenochroia elongella* and were negligible during the cropping season. In Bijapur area, five fields (Ukali, Mangoli, Hegadihal, Komar, and Katnali) were monitored in Bijapur district for pest surveillance. Mostly, M-35-1 was grown as a sole crop. The planting was done mostly during November-December. The shoot fly incidence was moderate to severe (25-45%), stem borer was up to 12%. Shoot bug damage was recorded about 10-38%. Interestingly aphid damage was recorded up to 60%. *Coccinellids* were observed in the month of January in some of farmer's field.

Maharashtra: In western Maharashtra, eight locations were surveyed in Ahemadnagar district. Phule Vasudha and local M-35-1 was grown as a sole crop during September-October. Overall incidence of shoot fly was moderate to high (~ 42%) when crop was planted in the first fortnight of September. The late sown crop (November-December) has very meager presence of shoot fly. This year the incidence of stem borer was very low (< 3 %). The appearance of sugarcane aphid was moderate to high 50-60 aphids/leaf and recorded up to 7 damage rating. The shoot bug incidence was low during seedling and later stage. The presence of *Coccinella* was sporadic in two fields (2-3/leaf). In Marathwada region, total 15 locations in Parbhani district were surveyed. Dagdi, Maldandi (M-35-1). Parbhani Moti and local variety was mainly cultivated. About 40 % crop was intercropped with safflower. The incidence of shoot fly was moderate (10-30 %) and stem borer was low (>10%). The infestation of corn plant hopper (< 4%) was low and the incidence of shoot bug was also low. Intercropping with safflower did not affect on the incidence of shoot fly and stem borer. In Vidarbha region, about fifteen farms were surveyed in three Washim, Akola, and Buldhana districts. The shoot fly incidence was moderate (10-15%), stem borer particularly peduncle damage was recorded up to 10%. Aphids (~40 aphids/leaf) was recorded where sorghum was grown near to wheat. No other insect pests were noticed.



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) (Loc: All centers)

In AVHT-DS comprising 20 entries comprising 4 hybrids, 5 experimental varieties, 1 commercial hybrid, 1 commercial variety, 1 local cultivar, 1 local check, 4 checks for other pests, 2 resistant (IS 2312, IS 2205) and one susceptible (DJ 6514) check were evaluated for resistance to key pests at 7 locations (Kovilpatti, Dharwad, Bijapur, Tandur, Rahuri, Parbhani, and Solapur).

Shoot fly (*Atherigona soccata*, Rond): Deadhearts caused by shoot fly at 21 DAE was recorded at Dharwad, Parbhani and Solapur. The range of deadhearts was from 24.30 to 62.70% with an average of 39.53% DH. All most all entries showed deadhearts on par with resistant check except SPH 1666 and SPH 1689 (Table 1.1). The data on deadhearts due to shoot fly at 14 DAE was recorded at Rahuri only. The range was from 10.2% to 62.4% with an average of 23.64% (Table 1.2). Deadhearts caused by the shoot fly was recorded at 28 DAE in Kovilpatti, Bijapur, Dharwad, Tandur, Rahuri, Parbhani and Solapur. The data from Kovilpatti, Bijapur and Tandur was discarded as the susceptible check DJ 6514 recorded < 70% deadhearts. The data from Rahuri could not be considered due to high CV (> 25%). Across the locations and genotypes none of test entries performed lower than resistant check. The range was from 28.7 to 82.9% DH with an average of 51.0% DH. At Solapur, SPV 2034 and SPV 2049 recorded significantly low deadheart percentage and significantly on par with resistant check, IS 2312 at 28 DAE (Table 1.1).

Morpho-physiological traits: Morpho-physiological traits such as seedling vigor and leaf glossiness have been recorded at Bijapur, Rahuri and Solapur. The lowest rating on seedling vigor and leaf glossiness was recorded in SPV 2033 and SPH 1689 respectively. They were on par with resistant check (Table 1.2). The data on plant height at flowering stage was recorded at Rahuri, Parbhani and Solapur during Rabi 2012. Data on plants with shoot fly eggs were recorded at 14 DAE in (Bijapur, Solapur and Parbhani) was statistically significant at 5% level. The percentage of plant infested with eggs was higher at Bijapur and Parbhani (53-85%) and were lower in Solapur. Overall, the entries SPH 1663, SPV 2033, SPV 2034, SPV 2035, SPV 2049, SPH 1690 and SPV 2104 recorded least egg infestation and were on par with resistant check IS 2205 (Table 1.1). The oviposition preference (eggs/5 plants) was recorded at Bijapur, Tandur and Rahuri. The range was from 2.78 to 13.44 eggs/5 plants with an average of 3.79 eggs per five plants (Table 1.2).

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 30 DAE, damage rating (1-9), deadhearts (%) at 45 DAE, stem tunneling (%) and peduncle damaged plants (%) at hot spot locations.

The data on percent injury leaf was recorded at 30 DAE at Kovilpatti, Tandur, Parbhani and Solapur. Across the locations and genotypes at national level, the data on leaf damage percentage was insignificant and ranged from 7.8-30.0% being an average of 18.63%. Amongst test entries, M 35-1 recorded lowest leaf damage % due to stem borer after resistant check IS 2205 (Table 1.3). The data on injury rating (1-9) was recorded at Kovilpatti and Tandur. Across the locations, the data on leaf damage rating was non-significant and ranged from 2.0-3.3 being an average of 2.5 in the scale of 1-9 (Table 1.3). The data on dead hearts at 45 DAE was recorded at Kovilpatti, Tandur and Parbhani. The overall mean of deadheart% due to stem borer at 45 DAE was ranged from 6.6 to 30.7 % being an average of 19.1%. Across the locations and genotypes, the data was significant at 5% level. The test entries SPV 2034, SPH 1690, Local check, C 43 and Y 75 were on par with resistant check IS 2205 (Table 1.3).

The peduncle tunneling (%) were recorded in Kovilpatti only. Across the genotypes, peduncle tunneling (%) ranged from 4.4-66.4% with an average of 30.45%. However, the data was not significant at 5% level. The least damage was recorded in TAM 428 (4.4%). Surprisingly, the resistant check IS 2205, recorded 49.6% peduncle tunneling (Table 1.3).

The data on peduncle damage due to stem borer was recorded at Kovilpatti and Tandur. The overall range of peduncle damage was from 5.56 to 50.25 % being an average of 31.43%. However, the CV% was high (>30%) and the data was non-significant having high CV% (<30%) could not be considered for discussion. The entry SPV 2035 recorded lowest peduncle damage (14.17%) after resistant check (Table 1.3).

Sugarcane aphid (*Melanaphis sacchari*, Zehntner): Plant damage due to sugarcane aphid was recorded in the scale of 1-9 at Bijapur, Rahuri and Parbhani. Across the locations, DJ 6514 recorded lowest damage rating 5.22. Plant damage rating was low in other testing entries viz; SPV 2033, SPV 2035, SPV 2049, SPH 1690, M-35-1 and were on par with resistant check (Table 1.3).

Shoot bug (*Peregrines maidis*, Ashmead): Shoot bug plant damage rating was recorded at Bijapur center only. The data was significant at 5% level. The range was recorded from 2.00 to 4.33 being an average of 2.90.

The test entries SPH 1666, SPV 2034, SPV 2035, SPV 2049 and SPH 1689 recorded lowest damage (<3.00) and were on par with DJ 6514 (Table 1.4). The data on shoot bug population (no/plant) was recorded at Bijapur centre only and was significant at 5% level. All test entries were on par with check. The data ranged from 14.0 to 39.67 being an average population of 23.20 per plant (Table 1.4).

The data on plant damage due to plant damage was recorded at Bijapur and Parbhani. Across the location the range was from 10.12-22.45 being an average of 15.96%. The data was not significant at 5% level. SPV 2140 recorded lowest plant damage due to shoot bug (Table 1.4).

Head bug (*Calocoris angustatus*): The head bug population density at milk stage was recorded at Kovilpatti. However the data was not significant at 5% level. Across the genotypes, the data ranged from 4.67 to 20.7 bugs plant⁻¹ averaging 12.3 bugs plant⁻¹. The lower (<10 bugs) bugs population density was observed in SPH 1663, CSH 15R, Local check and TAM 428 (Table 1.4). The data on damage rating due to head bug was recorded at Kovilpatti only. It was very low and the data was not significant at 5% level. The range was 1.00 to 3.00 being an average of 1.75 (Table 1.4).

Day to (50%) flowering: Days to 50% flowering were recorded at three centers i.e., Rahuri, Parbhani and Solapur. Across the locations and genotypes the shortest duration to flower was recorded in Hathikuntha (68.4 days) and the longest flowering was recorded in DJ 6514 (89.4 days) (Table 1.4).

Plant population per plot: The data on plant population per plot (2 rows of 2 m) was recorded at Tandur, Parbhani and Solapur. Across the genotypes and locations, the data on plant population was significant and ranged from 15 to 25 plants being an average of 19 plants plot⁻¹ (Table 1.4).

Grain yield & its components: Grain yield in grams per plant was assessed on the basis of 4 plant samples per plot and recorded at Rahuri, Parbhani and Solapur. When the test entries were exposed to biotic stresses, especially insects, the grain yield plant⁻¹ was recorded for all the test entries mentioned above. Overall, the range was 20.22 to 45.57 with a mean of 33.16 g plant⁻¹. However the data was not statistically significant at 5% level. Irrespective of locations the mean higher grain yield was obtained in SPH 1663 (45.57 g/ plant⁻¹) and it was on par with CSH 15R (Table 1.4).

Plant height (cm) at maturity: The data on plant height (cm) was recorded at Parbhani, Rahuri and Solapur. Across the locations, the data on plant height was significant. The plant height ranged from 97.86 to 214.67 cm plant⁻¹ with an average of 176.35 cm plant⁻¹. The highest plant height was recorded in SPH 1690 (214 cm) followed by SPV 2034. The shortest height was TAM 428 (97 cm) (Table 1.2).

Overall resistant rating : The data on overall rating on resistance was recorded at Solapur. The resistant rating scale was used 1-9. The entries that showed higher resistant rating (~ 4 rating) are SPH 16163, Hathikuntha, CSV 22, SPH 1690 SPV 2049 and SPV 2035 (Table 1.1)

Trial 2: Advanced Varietal & Hybrid Trial for shallow soil (AVHT-SS) (Loc: All centers)
In this trial, 18 entries comprising 1 hybrids 5 experimental varieties, 1 commercial hybrid, 3 commercial varieties, 2 resistant checks (IS 2312, IS 18551), 1 susceptible (DJ 6514) check, one local check and four other checks were evaluated for resistance to key pests at seven locations (Kovilpatti, Bijapur, Dharwad, Tandur, Rahuri, Parbhani and Solapur).

Shoot fly (*Atherigona soccata*, Rond): Deadhearts caused by shoot fly at 21 DAE was recorded at Dharwad, Parbhani and Solapur. The range of deadhearts was from 21.2 to 66.4% with an average of 37.03% DH. About 8 test entries showed deadhearts on par with resistant check (Table 1.1). The data on deadhearts due to shoot fly at 14 DAE was recorded at Rahuri only. The range was from 9.37 % to 50.27% with an average of 22.03% (Table 1.2). Deadhearts caused by the shoot fly was recorded at 28 DAE in Kovilpatti, Parbhani, Solapur, Dharwad, Bijapur, Rahuri, and Tandur. The data from Kovilpatti, Bijapur and Tandur and Rahuri was discarded as DJ 6514 (Sus check) recorded < 70% deadhearts. Among the experimental tests, Phule Anuradha, SPV 2034, SPV 204, SPV 2029, Mauli, SPV 2038, SPV 2031 and Local check recorded significantly low deadheart percentage and were significantly not different from the resistant check, IS 2312 at 21 and 28 DAE (Table 2.1).

Data on plants infested with shoot fly eggs were recorded at 14 DAE at Bijapur, Solapur and Parbhani and was statistically significant at 5% level. The percentage of plant infested with eggs was higher at Parbhani (18.91 to 83.55%) and were lower in Solapur (7.3 to 42.6). Overall, the entries SPV 2048, Phule Anuradha and SPV 2029 recorded least egg infestation and were on par with resistant check IS 2205 (Table 2.1). The oviposition preference (eggs/5 plants) was recorded at Bijapur, Tandur and Rahuri. The range was from 4.2 to 16.7 eggs/5 plants with an average of 7.3 eggs per five plants (Table 2.2).

Morpho-physiological traits: Morpho-physiological traits such as seedling vigor and leaf glossiness have been recorded at Bijapur, Rahuri and Solapur. The lowest rating on seedling vigor and leaf glossiness was recorded in Maulee and local check respectively. Across the locations the data on SPV 2029 recorded higher glossiness and seedling vigor (Table 2.2).

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 30 DAE, damage rating (1-9), deadhearts (%) at 45 DAE, stem tunneling (%) and peduncle damaged plants (%) at hot spot locations. The data on percent injury leaf was recorded at 30 DAE at Kovilpatti, Tandur, Parbhani and Solapur. The CV % was high (>25%). Across the locations and genotypes at national level, the data on leaf damage percentage was insignificant and ranged from 7.6 to 33.4 % being an average of 17.69 %. Amongst test entries, SPV 2048 recorded lowest leaf damage % due to stem borer after resistant check IS 2205 (Table 2.3). The data on injury rating (1-9) was recorded at Kovilpatti and Tandur. Across the locations, the data on leaf damage rating was non-significant. There was low damage range varied from 1.00 to 2.33 being an average of 1.57 in the scale of 1-9 (Table 2.3).

Data on deadhearts at 45 DAE caused by stem borer at Kovilpatti, Tandur, and Parbhani showed high CV (> 25%). At Tandur the higher range of stem borer dead hearts were recorded 4.6 to 61.6 % (Table 2.3). Overall Local check, SPV 2029, SPV 2031, CSH 15R recorded lower borer deadhearts. Peduncle damage was recorded at Kovilpatti and Tandur but due to high CV it was ignored to discuss. However, lowest peduncle damage was noticed in Local check, SPV 2048, Phule Anuradha (Table 2.3.)

The peduncle tunneling (%) were recorded in Kovilpatti only. Across the genotypes, peduncle tunneling (%) range varied from 3.4 to 72.2 % with an average of 35.1%. However, the data was not significant at 5% level (Table 2.3). The data on peduncle damage due to stem borer was recorded at Kovilpatti and Tandur. The overall range of peduncle damage was from 7.14 to 76.23 % being an average of 47.4%. However, the data was non-significant having high CV% (<30%) could not be considered. The entry SPV 2048 recorded lowest peduncle damage (14.17%) after resistant check (Table 2.3).

Sugarcane aphid (*Melanaphis sacchari*, Zehntner): Plant damage due to sugarcane aphid was recorded in the scale of 1-9 at Bijapur, Rahuri and Parbhani. Across the locations, Local check, SPV 2031 and SPV 2034 recorded lowest damage rating 6.33 and were on par with resistant check (Table 2.3).

Shoot bug (*Peregrines maidis*, Ashmead): Only Bijapur and Parbhani centre has recorded shoot bug plant damage rating. Shoot bug infestation was heavy at Bijapur. In general, Phule Anuradha, Y 75, CSH 15 R, Local check, SPV 2031 relatively had low plant damage of shoot bugs (Table 2.4). The data on shoot bug population (no/plant) was recorded at Bijapur centre only and was not significant at 5% level. The data ranged from 17.00 to 33.87 being an average population of 22.58 per plant (Table 2.4). The data on plant damage due to plant damage was recorded at Bijapur and Parbhani. Across the location the range was varied from 10.9 to 24.9 being an average of 18.7%. The data was not significant at 5% level. Phule Anuradha recorded lowest plant damage due to shoot bug (Table 2.4).

Head bug (*Calocoris angustatus*): The head bug population density at milk stage was recorded at Kovilpatti. However the data was not significant at 5% level. Across the genotypes, the data ranged from 6.3 to 21.7 bugs panicle⁻¹ averaging 11.6 bugs plant⁻¹. The lower (<10 bugs) bugs population density was observed in M 35-1, CSH 15R, C 43 and Y 75 (Table 2.4). The data on damage rating due to head bug was recorded at Kovilpatti only. It was very low and the data was not significant at 5% level. The range was 1.00 to 3.00 being an average of 1.67 (Table 2.4).

Day to (50%) flowering: Days to 50% flowering were recorded at Rahuri and Parbhani. Hathikunta, Phule Anuradha, Mauli, Y75, SPH 1665 recorded < 75 days to flower (Table 2.4).

Plant population per plot: The data on plant population per plot (2 rows of 2 m) was recorded at Tandur, Parbhani and Solapur. Across the genotypes and locations, the data on plant population was significant and ranged from 12.3 to 28.3 plants being an average of 18.2 plants plot⁻¹. The highest plant population was recorded in TAM 428 (Table 2.4).

Grain yield & its components: Grain yield in grams per plant was assessed on the basis of 4 plant samples per plot and recorded at Rahuri, Parbhani and Solapur. When the test entries were exposed to biotic stresses, especially insects, the grain yield plant⁻¹ was recorded for all the test entries mentioned above. Overall, the range was 26.10 to 63.63 with a mean of 48.20 g plant⁻¹. Across the locations the entries Mauli, SPH 1665, Local check, SPV 2034, SPV 2029 and SPV 2084 recorded >55 gm grain yield panicle⁻¹ (Table 2.4).

Plant height (cm) at maturity: The data on plant height (cm) was recorded at Parbhani, Rahuri and Solapur. Across the locations, the data on plant height was significant. The plant height ranged from 96 to 222 cm plant⁻¹ with an average of 184.42 cm plant⁻¹. The highest plant height was recorded in SPV2048 (222 cm) followed by SPV 2029. The shortest height was recorded in TAM 428 (96 cm) (Table 2.2).

Overall resistant rating: The data on overall rating on resistance was recorded at Solapur. The resistant rating scale was used 1-9. The entries that showed higher resistant rating (~ 4 rating) are SPV 2034, SPV 2048, SPV 2084 and Phule Anuradha (Table 2.1)

Trial 3: Initial Varietal and Hybrid Trial for deep soil (IVHT-DS) (Loc: All centers)

AVHT-DS comprised of 27 entries comprising 4 hybrids, 17 experimental varieties, 1 commercial hybrid, 1 commercial variety, 1 local check, 4 checks for other pests, 2 resistant (IS 2312, IS 2205) and one susceptible (DJ 6514) check were evaluated for resistance to key pests at 7 locations (Kovilpatti, Bijapur, Dharwad, Tandur, Rahuri, Parbhani, and Solapur).

Shoot fly (*Atherigona soccata*, Rond): Deadhearts caused by shoot fly at 21 DAE was recorded at Dharwad, Parbhani and Solapur. The range of deadhearts was from 17.45% with an average of 33.54% DH. All most all entries showed deadhearts on par with resistant check IS (2312) except SPV 2146, SPV 2150, SPV 2149 (Table 3.1). Deadhearts caused by the shoot fly was recorded at 28 DAE in Kovilpatti, Bijapur, Dharwad, Tandur, Rahuri, Parbhani and Solapur. The data from Kovilpatti, Bijapur and Tandur was discarded as the susceptible check DJ 6514 recorded < 70% deadhearts. The data from Rahuri and Parbhani could not be considered due to high CV (> 25%). At Dharwad, SPV2139, SPV 2141, SPV 2152, SPV 2138, SPV 2153, SPV 2143, CSV 22, Local check, CSH 15 R, SPV 2154 were on par with check. At Solapur, SPV 2140, SPV 2139, SPV 2141, 2141, Y 75, SPV 2142, SPV 2152, SPH 1720, SPV 2145, SPH 1721 and SPV 2143 recorded significantly low deadheart percentage and significantly on par with resistant check, IS 2312 at 28 DAE. Across the locations and genotypes none of test entries performed lower than resistant check. The range was from 29.64 to 79.16% DH with an average of 49.67% DH. The entries SPV 2141, SPV 2139, SPV 2152, SPV 2138 and SPV 2143 recorded significantly low deadheart % and significantly on par with resistant check, IS 2312 at 28 DAE (Table 3.1).

Morpho-physiological traits: Morpho-physiological traits such as seedling vigor and leaf glossiness have been recorded at Bijapur, Rahuri and Solapur. The lowest rating on seedling vigor and leaf glossiness was recorded in SPV 2149 and SPV 2138, respectively. They were on par with resistant check (Table 3.2). The data on plant height at flowering stage was recorded at Rahuri, Parbhani and Solapur during Rabi 2012. Data on plants with shoot fly eggs were recorded at 14 DAE in (Bijapur, Tandur and Rahuri) was statistically significant at 5% level. The percentage of plant infested with eggs was recorded at Dharwad, Parbhani and Solapur. Higher infestation was recorded at Dharwad (57.77%) followed by Parbhani (28.65%) and Solapur (13.66%). Overall, the entries SPV 2152, SPV 2139, SPV 2141, SPV 2154, Local check and SPV 2138 recorded least egg infestation (Table 3.1). The oviposition preference (eggs/5 plants) was recorded at Bijapur, Tandur and Rahuri. The range was from 4.94 to 8.33 eggs/5 plants with an average of 6.37 eggs per five plants (Table 3.2).

Spotted stem borer (*Chilo partellus*, Swinhoe): The data on stem borer was recorded at 4 centers (Kovilpatti, Tandur, Parbhani and Solapur). The data on spotted stem borer infestation was assessed in terms of stem borer leaf injury plants (%), damage rating (1-9) borer deadhearts (%) and stem borer peduncle damage (%). The data on percent injury leaf was recorded at 30 DAE at Kovilpatti, Tandur, Parbhani and Solapur. Across the locations and genotypes at national level, the data on leaf damage percentage was insignificant and ranged from 7.63 – 32.84 % the average being 19.23%. Amongst test entries CSV 22, SPV 2141, SPV 2152 and SPV 2145 recorded lowest leaf damage % due to stem borer after resistant check IS 2205 (Table 3.3). The data on injury rating (1-9) was recorded at Kovilpatti and Tandur. Across the locations, the data on leaf damage rating was non-significant and ranged from 1.0-3.5 with an average of 2.4 on the scale of 1-9 (Table 3.3).

The data on dead hearts at 45 DAE was recorded at Kovilpatti, Tandur and Parbhani. The overall mean of deadheart% due to stem borer at 45 DAE was ranged from 5.4 to 36.0 % with an average of 20.1%. Across the locations and genotypes, the data was significant at 5% level. The test entries SPV 2152 was on par with resistant check IS 2205 (Table 3.3). The peduncle tunneling (%) were recorded in Kovilpatti only. Across the genotypes, peduncle tunneling (%) ranged from 8.5 – 35.25 % with an average of 21.06%. However, the data was not significant at 5% level. The least damage was recorded in CSH 15R, surprisingly, the resistant check IS 2205, recorded 35.07 % peduncle tunneling (Table 3.3).

The data on peduncle damage due to stem borer was recorded at Kovilpatti and Tandur. The overall range of peduncle damage was from 12.64 – 55.9 % being an average of 33.39%. However, the CV% was high (>30%) and the data was non-significant and could not be considered for discussion. The entry SPV 2144, recorded lowest peduncle damage (18.73%) after resistant check (Table 3.3).

Sugarcane aphid (*Melanaphis sacchari*, Zehntner): Plant damage due to sugarcane aphid was recorded in the scale of 1-9 at Bijapur, Rahuri and Parbhani. Across the locations, DJ 6514 recorded lowest damage rating 4.78. Plant damage rating was low in other testing entries viz; CSH 15R, SPV 2144, SPV 2154, SPV 2153, SPH 1720, SPV 2145, SPV 2142, CVS 22, SPV 2139, Local check and SPV 2151 and were on par with resistant check (Table 3.3).

Shoot bug (*Peregrines maidis*, Ashmead): Shoot bug plant damage rating was recorded at Bijapur center only. The range was recorded from 1.67 to 4.33 with an average of 3.15. The test entries SPV 2150 and CSH 15 R recorded lowest damage (<3.00) and were on par with DJ 6514 (Table 3.4). The data on shoot bug population (no/plant) was recorded at Bijapur centre only and was significant at 5% level. The data ranged from 16.0 to 39.33 with an average population of 26.22 per plant. The test entries SPV 2150, SPV2142, SPV 2140, CSH 15 R, SPV 2154 and CSV 22 recorded lowest damage (< 2.63) and were on par with DJ 6514 (Table 3.4).

The data on plant damage due to plant damage was recorded at Bijapur and Parbhani. Across the location the range was from 13.47 – 24.13 % with an average of 18.8 %. The entries Local check, SPV 2151, SPH 1721, SPV 2146, CSH 15R and SPV 2150 recorded lowest plat damage due to shoot bug (Table 3.4).

Head bug (*Calocoris angustatus*): The head bug population density at milk stage was recorded at Kovilpatti. Across the genotypes, the data ranged from 8.3 – 24.3 bugs plant⁻¹ averaging 15.8 bugs plant⁻¹. The lower (<10 bugs) bugs population density was observed in TAM 428 and SPV 2146 (Table 3.4). The data on damage rating due to head bug was recorded at Kovilpatti only. It was very low and the data was not significant at 5% level. The range was 1.3 to 3.3 being an average of 2.15. The entries SPV 2139, SPV 2140 and SPV 2154 were most susceptible recording damage rating over 2.76. Rests of the entries were on par with each other (Table 3.4).

Day to (50%) flowering: Days to 50% flowering were recorded at three centers i.e., Rahuri, Parbhani and Solapur. Across the locations and genotypes the shortest duration to flower was recorded in Hathikuntha (68.8 days) and the late flowering was recorded in SPV 2142 (89.2 days) (Table 3.4).

Plant population per plot: The data on plant population per plot (2 rows of 2 m) was recorded at Tandur, Parbhani and Solapur. Across the genotypes and locations, the data on plant population was significant and ranged from 9.6 - 29 plants being an average of 21 plants plot⁻¹ (Table 3.4).

Grain yield & its components: Grain yield in grams per plant was assessed on the basis of 4 plant samples per plot and recorded at Rahuri, Parbhani and Solapur. The test entries were exposed to biotic stresses, especially insects and the grain yield plant⁻¹ was recorded for all the test entries. Overall, the range was 13.41 to 56.72 g plant⁻¹ with a mean of 38.25 g plant⁻¹. However the data was not statistically significant at 5% level. Irrespective of locations the mean higher grain yield was obtained in the test entry SPH 1721 (49.92 g/ plant⁻¹) and it was on par with CSH 15R (Table 3.4).

Plant height (cm) at maturity: The data on plant height (cm) was recorded at Rahuri, Parbhani and Solapur. Across the locations, the data on plant height was significant. The plant height ranged from 91.0 to 198.0 cm plant⁻¹ with an average of 172.82 cm plant⁻¹. The highest plant height was recorded in SPV 2145 (198 cm) followed by SPV 2153 (197 cm plant⁻¹). The shortest height was TAM 428 (91 cm) (Table 3.2).

Overall resistant rating: The data on overall rating on resistance was recorded at Solapur. The resistant rating scale was used 1-9. The entries that showed higher resistant rating (~ 4 rating) are SPV 2140, SPV 2139, SPV 2138, Local check and CSV 22 (Table 3.1)

Trial 4: Initial Varietal and Hybrid Trial for shallow soil (IVHT-SS) (Loc: All centers)

In this trial, 10 experimental varieties, 1 hybrid check, 1 commercial check, 1 local landrace (M 35-1), Maulee, 1 local check along with 2 resistant (IS 2312, IS 2205), 1 susceptible check (DJ 6514) and 4 other checks for remaining pests were evaluated for resistance to key pests at 7 test locations (Kovilpatti, Bijapur, Dharwad, Tandur, Rahuri, Parbhani and Solapur). Total twenty two varieties and hybrids were put for evaluation.

Shoot fly (*Atherigona soccata*, Rond): Deadhearts caused by shoot fly at 21 DAE was recorded at Dharwad, Parbhani and Solapur. The range of deadhearts was from 20.28 to 59.50% with an average of 37.61% DH. The test entries SPV 2159, SPV 2160, M-35-1 and Phule Anuradha showed low deadhearts and were on par with resistant check (Table 4.1). The data on deadhearts due to shoot fly at 14 DAE was recorded at Rahuri only. The range was from 9.07 % to 43.37% with an average of 25.38% (Table 4.2). Deadhearts caused by the shoot fly was recorded at 28 DAE in Kovilpatti, Parbhani, Solapur, Dharwad, Bijapur, Rahuri, and Tandur. The data from Kovilpatti, Bijapur and Tandur and Rahuri was discarded as DJ 6514 (Sus check) recorded < 70% deadhearts. Among the experimental tests SPV 2160 recorded significantly low deadheart percentage and followed by Phule Anuradha and were significantly not different from the resistant check, IS 2312 at 28 DAE (Table 4.1).

Data on plants infested with shoot fly eggs were recorded at 14 DAE at Bijapur, Parbhani and Solapur was statistically significant at 5% level. The percentage of plant infested with eggs was higher at Parbhani (20.30 to 76.03%). Across the locations, the egg infestation % ranged from 17.31 to 52.56 % being an average of 32.17%. The entries SPV 2155, SPV 2158, SPV 2159, SPV 2160, SPV 2161 and Phule Anuradha recorded least percentage of plant infested with eggs (<28%) and were on par with resistant check IS 2205 (Table 4.1). The oviposition preference (eggs/5 plants) was recorded at Bijapur, Tandur and Rahuri. The range was from 2.78 to 7.56 eggs plants⁻⁵ with an average of 4.25 eggs plants⁻⁵ (Table 4.2).

Morpho-physiological traits: Morpho-physiological traits such as seedling vigor and leaf glossiness have been recorded at Bijapur, Rahuri and Solapur. The data on seedling vigor and glossiness was non-significant at 5% level. The lowest rating on seedling vigor was recorded in SPV 2157 (3.67) and the lowest glossiness SPV 2160 after the resistant check (Table 4.2).

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 30 DAE, damage rating (1-9), deadhearts (%) at 45 DAE, stem tunneling (%) and peduncle damaged plants (%) at hot spot locations. The data on percent injury leaf was recorded at 30 DAE at Kovilpatti, Tandur, Parbhani and Solapur. The CV % was high (>25%) across the locations. Overall, the data on leaf damage percentage was insignificant and ranged from 7.00 to 27.43 % being an average of 18.89 %. Amongst test entries, SPV 2157, SPV 2159, CSH 15R, Maulee and Hathikuntha recorded lowest (~17%) plant injury due to stem borer after resistant check IS 2205 (Table 4.3). The data on injury rating (1-9) was recorded at Kovilpatti and Tandur. Across the locations, the data on leaf damage rating was non-significant. There was low damage and range varied from 1.00 to 3.33 being an average of 2.2 in the scale of 1-9 (Table 4.3).

Data on deadhearts at 45 DAE caused due to stem borer at Kovilpatti, Tandur and Parbhani showed high CV (> 25%). At Tandur the higher range of stem borer deadhearts were recorded 8.0 to 63.8 % being an average of 17.7% (Table 4.3). Across the locations almost all entries were on par except SPV 2155, SPV 2163 and CSH 15R. Peduncle damage was recorded at Kovilpatti and Tandur but due to high CV it was considered. However, lowest peduncle damage was noticed in Y 75. The peduncle tunneling (%) were recorded in Kovilpatti only. The data was not significant at 5% level and had high CV% (Table 4.3).

Sugarcane aphid (*Melanaphis sacchari*, Zehntner): Plant damage due to sugarcane aphid was recorded in the scale of 1-9 at Bijapur, Rahuri and Parbhani. At Bijapur and Rahuri the plant damage due to aphid was high 5.00-8.00. Across the locations, the lowest plant damage was recorded in TAM 428 (Table 4.3).

Shoot bug (*Peregrines maidis*, Ashmead): Only at Bijapur centre has recorded shoot bug plant damage rating and was ranged from 1.33 to 3.33 averaging 2.32 damage rating. The data on shoot bug population (bugs plant⁻¹) was recorded at Bijapur centre only and was not significant at 5% level. The data ranged from 15.5 to 37.4 being an average population of 24.0 bugs plant⁻¹ (Table 4.4). The plant % damage due to shoot bug was recorded at Bijapur and Parbhani. Across the locations, C 43, SPV 2161, SPV 2160, SPV 2162 and Maulee relatively had low plant damage due to shoot bug (12 bugs plant⁻¹). Across the location the range was varied from 9.96 to 21.7 being an average of 13.9% (Table 4.4).

Head bug (*Calocoris angustatus*): The head bug population density at milk stage was recorded at Kovilpatti. However the data was not significant at 5% level. Across the genotypes, the data ranged from 3.33 to 23.7 to 21.7 bugs panicle⁻¹ averaging 11.3 bugs plant⁻¹. The lower (<10 bugs) bugs population density was observed in SPV 2157, SPV 2163, CSH 15R, M-35-1, TAM 428 and DJ 6514 (Table 4.4). The data on damage rating due to head bug was recorded at Kovilpatti only. It was very low and the data was not significant at 5% level. The range was 1.00 to 3.00 being an average of 1.71 (Table 4.4).

Day to (50%) flowering: Days to 50% flowering were recorded at Rahuri, Parbhani and Solapur. Hathikunta recorded earliest flowering 66 days, while DJ 6514 recorded longest days to flower (87 days) (Table 4.4).

Plant population per plot: The data on plant population per plot (2 rows of 2 m) was recorded at Tandur, Parbhani and Solapur. Across the genotypes and locations, the data on plant population was significant and ranged from 12 to 28 plants being an average of 21 plants plot⁻¹. The highest plant population was recorded in C 43 (Table 4.4).

Grain yield & its components: Grain yield in grams per plant was assessed on the basis of 4 plant samples per plot and recorded at Rahuri, Parbhani and Solapur. When the test entries were exposed to biotic stresses, especially insects, the grain yield plant⁻¹ was recorded for all the test entries mentioned above. Overall, the range was 15.71 to 46.81 g plant⁻¹ with a mean of 32.72 g plant⁻¹. SPV 2154 recorded highest grain yield (46.8 g panicle⁻¹) (Table 4.4).

Plant height (cm) at maturity: The data on plant height (cm) was recorded at Rahuri, Parbhani and Solapur. Across the locations, the data on plant height was significant. The plant height ranged from 97 to 190 cm plant⁻¹ with an average of 163.59 cm plant⁻¹. The highest plant height was recorded in SPV2048 (222 cm) followed by SPV 2029. The shortest height was recorded in SPV 2155 (190 cm) and lowest plant height was recorded in TAM 428 (97cm) (Table 4.2).

Overall resistant rating: The data on overall rating on resistance was recorded at Solapur. The resistant rating scale was used 1-9. The entry that recorded higher resistant rating (~ 4 rating) was SPV 2160 (Table 4.1).

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

Trial 5: SFR materials from Germplasm for shoot fly resistance (SFR-F5-SF) (Loc: Hyderabad, Rahuri and Parbhani)

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 and Hyderabad during Rabi 2011-12. It comprises 32 entries having 14 selected crosses, 14 parental lines, 1 popular check (M-35-1), 1 resistant check (IS 2312), 1 susceptible check (DJ 6514) and 1 local check. 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 14, 21 and 28 DAE. The data were also collected on seedling vigor, glossiness, shoot fly eggs/5 plants and seedling (%) infested with eggs

Shoot fly (Atherigona soccata, Rond)

Shoot fly deadhearts at 28 DAE: Deadhearts caused by shoot fly at 28 DAE was recorded at Rahuri, Parbhani and Hyderabad. The range of deadhearts was from 29.52- 76.23 % with an average of 39.02% DH. The data were significant at 5% irrespective of locations. Overall, almost all entries were on par with resistant check IS 2312 except CSV 15 x EC 19-5-1, EC 19, PV 25 and PEC 1, SSV 84. The first five lowest deadhearts recorded progenies were EC 12 x EP 133-5-2, EC 12 x POP 52-3-1, EC 19 x EP 133-2-3, PEC 9 and LG Kumbhari local (Table 5.1).

Shoot fly deadhearts at 18 DAE: The data on deadhearts due to shoot fly at 21 DAE was recorded at Parbhani and Hyderabad. The range was from 15.29 to 51.18% with an

Shoot fly deadhearts at 14 DAE: average of 26.2% (Table 5.1). The progeny EC 12 x POP 52-3-1 recorded lowest deadhearts (15.3%) at 21 DAE. The data on deadhearts at 14 DAE was recorded at Rahuri only. The range was varied from 6.71 to 40.63 % with an average of 15.23% (Table 5.2).

Oviposition preference: The data on infested seedling with shoot fly eggs at 14 DAE were recorded at Parbhani and Hyderabad. Overall the data was statistically not significant at 5% level. The percentage of plant infested with eggs was higher at Parbhani (14.78 to 74.25 %). Across the locations, the egg infestation % ranged from 11.57 to 49.29 % being an average of 30.22%. The progenies EC 12 x POP 52-3-1, (PEC 1 x LG kumbharo local) x EC 19-6-2, EC 133 x EC 13-2-1, EC 12 x EP 133-5-2, EC 12 x EP 133-5-2, EC 19 x EP 133-2-3, EC 15 x EP 57-6-1, CSV 216R x EP 133-2-1, and CSV 22 x EC 12-4-1 recorded least percentage of plant infested with eggs (<28%) and were on par with resistant check IS 2312 (Table 5.1). The data on oviposition (egg/ 5 plants) was recorded at Rahuri only and very low oviposition was recorded (2.0 to 6.0 with an average of 2.3 eggs per 5 plants (Table 5.2).

Morpho-physiological traits: Morpho-physiological traits such as seedling vigor and leaf glossiness have been recorded at Rahuri and Hyderabad. Overall, the data on seedling vigor and glossiness was non-significant at 5% level. The lowest rating on seedling vigor was recorded in CPV 22 (3.5) and the lowest glossiness was recorded in local check (M 35-1 or Vasudha) (Table 5.2).

Day to (50%) flowering: Days to 50% flowering were recorded at Rahuri, Parbhani and Hyderabad. The range was varied from 74 to 87 with an average of 79 days to flower. LG local kumbhari recorded earliest flowering 74 days, while DJ 6514 recorded longest days to flower (87 days) (Table 5.2).

Plant population per plot: The data on plant population per plot (2 rows of 2 m) was recorded at Parbhani and Hyderabad. Across the genotypes and locations, the data on plant population was significant and ranged from 17 to 29 plants being an average of 23 plants plot⁻¹. The highest plant population was recorded in PV 25 (Table 5.3).

Grain yield & its components: Grain yield in grams per plant was assessed on the basis of 4 -5 plant samples per plot and recorded at Rahuri, Parbhani and Hyderabad. When the test entries were exposed to biotic stresses, especially insects, the grain yield plant⁻¹ was recorded for all the test entries mentioned above. Overall, the range was 29.48 to 73.23 g plant⁻¹ with a mean of 51.08 g plant⁻¹. CSV 22 recorded highest grain yield (73 g panicle⁻¹) and the lowest was recorded in DJ 6514 (Table 5.3).

Plant height (cm) at maturity: The data on plant height (cm) was recorded at Rahuri, Parbhani and Hyderabad. Across the locations, the data on plant height was significant. The plant height ranged from 170.3 to 217.8 cm plant⁻¹ with an average of 196.8 cm plant⁻¹. The highest plant height was recorded in EC 19 x EP 133-2-3 (218cm) followed by local check. The shortest height was recorded in DJ 6514 (170 cm) (Table 5.2).

Overall resistant rating (1-9): The data on overall rating on resistance was recorded at Solapur. The resistant rating scale was used 1-9. The entry that recorded higher resistant rating (3.3 rating) was SSV 84 and lowest resistant rating was recorded in CSV 22 x EC 12-4-1 (6.0 rating) (Table 5.1).

Trial 6: Evaluation of local checks of different centers shoot fly and stem borer resistance (LC-SF&SB) (Loc: Kovilpatti, Bijapur, Dharwad and Solapur)

The collaborative efforts of Entomologist have initiated from 2007 to search for new resistant sources in local checks that are using in AICSIP entomology trials from respective centers. The trial comprised of total 12 entries with 9 from different centers, 1 resistant, 1 local check and 1 susceptible check. The trial was conducted at five locations: Kovilpatti, Dharwad, Bijapur and Solapur.

Shoot fly (Atherigona soccata, Rond)

Oviposition preference: The data on shoot fly oviposition (egg/5 plants) were recorded at Bijapur. Across the genotypes, there was a not significant difference in oviposition and it was ranged from 4.33 to 7.33 with an average of 6.19 eggs per 5 plants. Parbhani Moti preferred most for oviposition by female shoot fly, followed by DSV 5 (Table 6.1). The range of seedlings % with eggs was 14.32 to 30.06% with an average of 19.18 %. The entries Phule Anuradha and DSV 4 recorded lowest plant infestation (<15%) with eggs and found on par with resistance check IS 2312 (Table 6.2).

Shoot fly deadhearts at 28 DAE: The data on shoot fly deadhearts at 28 DAE were recorded at Kovilpatti, Dharwad, Bijapur and Solapur. The data on shoot fly deadhearts at 28 DAE was not significant at 5% level. The shoot fly deadhearts in DJ 6514 at Kovilpatti and Bijapur was <70%, hence could not considered for national average. Across the locations, the range of shoot fly deadhearts at 28DAE was 33.56 to 83.35% with an average of 49.18%. The local checks, DSV 4, DSV 5, CSV 22, Phule Anuradha and M 35-1 were on par with resistant check IS 2312 (Table 6.1).

Shoot fly deadhearts at 21 DAE: The data on shoot fly deadhearts at 21 DAE were recorded at Dharwad, and Solapur. Across the locations, the data on shoot fly deadhearts at 21 DAE was not significant. Across the locations and the entries the deadhearts range varied from 16.34 to 60.62 % with an average of 33.14 %. The entries CSV 22, M-35-1, CSV 216R recorded <25% deadhearts at 21 DAE (Table 6.1).

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 30 DAE, damage rating (1-9), deadhearts (%) at 45 DAE, stem tunneling (%) and peduncle damaged plants (%) at hot spot locations. The data on percent injury leaf was recorded at 30 DAE at Kovilpatti and Solapur. The CV % was high (>25%) across the locations. Overall, the data on leaf damage percentage was insignificant and ranged from 7.8 to 21.0 % being an average of 14.0 % (Table 6.2). The data on injury rating (1-9) was recorded at Kovilpatti. The data on leaf damage rating was non-significant. There was low damage rating and range varied from 1.67 to 2.67 being an average of 2.08 in the scale of 1-9 (Table 6.2).

Data on deadhearts at 45 DAE caused due to stem borer at Kovilpatti showed high CV (> 25%). The data on stem borer deadhearts were varied from 8.18 to 24.63 % being an average of 13.09 % (Table 6.2). Almost all entries were on par except CSV 22. Peduncle damage and peduncle tunneling was recorded at Kovilpatti, but due to high CV it was considered (Table 6.2).

Head bug (Calocoris angustatus): The head bug population density at milk stage was recorded at Kovilpatti. The data was significant at 5% level. Across the genotypes, the data ranged from 5.67 to 23.33 bugs panicle⁻¹ averaging 11.14 bugs plant⁻¹. The lower (<7 bugs) bugs population density was observed in Parbhani Moti, K-8 and M-35-1 (Table 6.2). The data on damage rating due to head bug was recorded at Kovilpatti only. It was very low and the data was not significant at 5% level. The range was 1.67-2.67 being an average of 2.14 (Table 6.2).

Morpho-physiological traits: Morpho-physiological traits such as seedling vigor and leaf glossiness have been recorded at Bijapur and Solapur. Overall, the data on seedling vigor and glossiness was non-significant at 5% level. The lowest rating on seedling vigor was recorded in CSV 216R (4.5) and the lowest glossiness was recorded in DSV 5 (3.83) (Table 6.2).

Day to (50%) flowering: Days to 50% flowering were recorded at Solapur. The range was varied from 71 to 88 with an average of 78 days to flower. Phule Anuradha recorded earliest flowering days (71 days), while DJ 6514 recorded longest days to flower (88 days) (Table 6.2).

Plant population per plot: The data on plant population per plot (2 rows of 2 m) was recorded at Solapur. Across the genotypes, the data on plant population was significant and ranged from 20 to 33 plants being an average of 26 plants plot⁻¹. The highest plant population was recorded in DJ 6514 (Table 6.2).

Grain yield & its components: Grain yield in grams per plant was assessed on the basis of 4 -5 plant samples per plot and recorded at Solapur. When the test entries were exposed to biotic stresses, especially insects, the grain yield plant⁻¹ was recorded for all the test entries mentioned above. Overall, the range was 7.57 to 24.47 g plant⁻¹ with a mean of 15.29 g plant⁻¹. Parbhani Moti recorded highest grain yield (25 g panicle⁻¹) and the lowest was recorded in CSV 15 (Table 6.2).

Plant height (cm) at maturity: The data on plant height (cm) was recorded at Solapur. Across the locations, the data on plant height was significant. The plant height ranged from 126 to 200 cm plant⁻¹ with an average of 162 cm plant⁻¹. The highest plant height was recorded in Parbhani Moti (200 cm) followed by local check M 35-1. The shortest height was recorded in K-8 (126 cm) (Table 6.2).

Trial 7: Screening of B& R lines for shoot fly resistance (B&R lines-SF) (Loc: Dharwad, Rahuri and Solapur)

Twenty five SLB and B&R lines contributed by Solapur including resistant, susceptible and local checks were evaluated for resistance to major pests at three locations (Dharwad, Rahuri and Solapur).

Shoot fly (*Atherigona soccata*, Rond): The data on seedlings with shoot fly eggs and oviposition (eggs/5plant) were recorded at Rahuri. Across the entries, the data were low in most of the entries and found non-significant (Table 7.1). The data on seedling infested with eggs were recorded at Solapur and was significant at 5% level. The range was from 5.83 to 17.94 being an average of 9.47% (Table 7.1). The deadhearts percentage caused by shoot fly at 21 DAE was recorded at Dharwad and Solapur. The data across the locations was non-significant at 5% level. The range was from 14.13 to 56.91 being an average of 29.8%. (Table 7.1).

The deadhearts percentage caused by shoot fly at 14 DAE was recorded at Rahuri. The data across the locations was significant at 5% level. The range was from 13.6 to 49.9 being an average of 27.4% (Table 7.1). The deadhearts percentage due to shot fly at 28 DAE was recorded at Dharwad, Rahuri and Solapur. The data was significant at 5% level. Across the locations, the range varied from 31.1 to 78.6% being a mean of 49.7%. The entries SLB 50 and SLB 25-1 recorded low deadhearts (<43%) across the three locations and were on par with resistant check IS 2312 (Table 7.1).

Spotted stem borer (*Chilo partellus*, Swinhoe): The data on leaf injury or damage (%) due to stem borer was low to moderate (3.42 to 34.64 %) averaging 10.56%. The data was significant. The entries that showed relatively low leaf damage (<6.5%) and found on par with resistant check (IS 2205) are: SLB 50, SLB 56, SLB 59, SLB 71, SLB 72, SLR 72 and SLR 73 (Table 7.1).

Sugarcane aphid (*Melanaphis sacchari*, Zehntner): Sugarcane aphid plant damage rating was recorded at Rahuri centre. The damage rating caused due to sugarcane aphid was ranged from 6.33 to 8.00 with an average of 7.36. High damage rating was recorded in almost all entries. The entry SLR 73 recorded lowest damage rating (6.33) (Table 7.2).

Morpho-physiological traits: Morpho-physiological traits such as seedling vigor and leaf glossiness have been recorded at Rahuri and Solapur. Overall, the data on seedling vigor and glossiness was non-significant at 5% level. The lowest rating on seedling vigor was recorded in SLB 25-1 (4.0) after resistant and local check. The lowest glossiness was recorded in SLR 72 (3.0) after resistant check (Table 7.2).

Days to 50% flowering: It was recorded at Solapur. The range was from 65 to 83 with an average of 79 days to flower. SLB 54 had shown significantly early flowering (65 days) among the entries. SLR 49 recorded late flowering (83 days) (Table 7.3).

Plant population per plot: The data on plant population per plot (2 rows of 2 m) was recorded at Solapur. Across the genotypes, the data on plant population was not significant and ranged from 21 to 31 plants being an average of 27 plants plot⁻¹. The highest plant population was recorded in DJ 6514 (Table 7.2).

Plant height (cm) at maturity: The plant height (cm) was recorded at Rahuri and Solapur centre. The data found to be significant. Maximum plant height was recorded in IS 2205 (205 cm) and the minimum plant height was noticed in SLB 55 (132 cm). The average plant height was recorded 171 cm (Table 7.3).

Grain yield & its components: Grain yield was recorded at Rahuri only. The range was 16- 108 plants. The entries SLB 25-1, SLB 39-1, SLB 56, SLB 60, SLB 67 and SLR 73 recorded higher grain yield (up to 80 g/plant) (Table 7.2)

Overall resistant rating (1-9): The data on overall rating on resistance was recorded at Solapur. The resistant rating scale was used 1-9. The entry that recorded higher resistant rating (3.3 rating) was SLB 39-1 and lowest resistant rating was recorded in SLB 67 (7.33 rating) (Table 7.1).

Trial 8: Screening of advanced lines for shoot fly resistance (ASFN) (Loc: Dharwad, Rahuri Parbhani and Solapur)

In Advanced Shoot fly Nursery (ASFN), 14 elite lines, one land race (M 35-1), 4 resistant checks, one susceptible were evaluated for resistance to shoot fly at four locations: Dharwad, Rahuri, Parbhani and Solapur

Shoot fly (*Atherigona soccata*, Rond)

Oviposition preference: The data on shoot fly oviposition (egg/5 plants) were recorded at Rahuri. Across the genotypes, there was a not significant difference in oviposition and it was ranged from 1.67 to 5.00 with an average of 2.92 eggs per 5 plants. RSV 1188 and local check least oviposition (Table 8.1). The range of seedlings % with eggs was recorded at Parbhani and Solapur and ranged from 18.43 to 65.09% with an average of 29.01 %. The entries RSE 03 recorded lowest plant infestation with eggs (19.8%) and was on par with resistance check IS 2312 (Table 8.1).

Shoot fly deadhearts at 14 DAE: The data on shoot fly deadhearts at 14 DAE were recorded at Rahuri. The data on shoot fly deadhearts at 14 DAE was significant at 5% level. Across the genotypes, the range of shoot fly deadhearts was from 11.9 to 49.0 % with an average of 49% (Table 8.1)

Shoot fly deadhearts at 21 DAE: The data on shoot fly deadhearts at 21 DAE were recorded at Dharwad, Parbhani and Solapur. Across the locations, the data on shoot fly deadhearts at 21 DAE not significant. Across the locations and the entries the deadhearts range varied from 14.91 to 65.56 % with an average of 25.41 %. The entries NRCSFPR09-1, NRCSFPR09-3, RSV 1315, RSV 1188, RSV 1003 and RSE 03 recorded <24% deadhearts at 21 DAE (Table 7.1).

Shoot fly deadhearts at 28 DAE: The data on shoot fly deadhearts at 28 DAE were recorded at Dharwad, Rahuri, Parbhani and Solapur. Across the locations, the data on shoot fly deadhearts at 28 DAE was significant at 5% level. Overall, the range of shoot fly deadhearts at 28DAE was 33.1 to 80.7% with an average of 43.3%. The entries NRCSFPR09-3, NRCSFPR10-4, RSE 03 and M 35 x RR 9808 were on par with resistant check IS 2312 (Table 8.1).

Morpho-physiological traits: Morpho-physiological traits such as seedling vigor and leaf glossiness have been recorded at Rahuri and Solapur. Overall, the data on seedling vigor and glossiness was non-significant at 5% level. The lowest rating on seedling vigor was recorded in M 35 x RR 9808 (3.5) after resistant and local check. The lowest glossiness was recorded in RSV 1315 (3.5) after resistant check (Table 8.2).

Days to 50% flowering: It was recorded at Parbhani, Rahuri and Solapur. The range was from 77 to 82 with an average of 79 days to flower. RSE 03 had shown significantly early flowering (77days) among the entries and the entry NRCSFPR09-1 recorded delayed flowering (82 days) (Table 8.3).

Plant population per plot: The data on plant population per plot (2 rows of 2 m) was recorded at Parbhani and Solapur. Across the locations and genotypes, the data on plant population was not significant and ranged from 16 to 26 plants being an average of 22 plants plot⁻¹. The highest plant population was recorded in IS 2205 (8.3).

Plant height (cm) at maturity: The plant height (cm) was recorded at Rahuri, Parbhani and Solapur centre. The data found to be significant at 5% level. Across the locations, minimum plant height was recorded in RSV 1306 (108 cm) and the maximum plant height was noticed in RSV 1188 (207 cm). The average plant height was recorded 171 cm (Table 8.2).

Grain yield & its components: Grain yield was recorded at Rahuri, Parbhani and Solapur. The range was from 18 to 51gm/ plant. The entries 73 recorded higher grain yield (up to 80 g/plant). The entries, RSV 1003, RSV 1188, NRCSFPR09-3, PSFRS-4-09, RSV 1313 and M 35 x RR 9808 recorded higher grain yield (>32 gm/plant) (Table 8.3).

Overall resistant rating (1-9): The data on overall rating on resistance was recorded at Solapur. The resistant rating scale was used 1-9. The entry that recorded higher resistant rating (3.7 rating) was RSE 03 and lowest resistant rating was recorded in DJ 6514 and 104B (>6.5 rating) (Table 8.3).

Trial 9: Evaluation of elite material for sugarcane aphids and shoot bug resistance (APSHN) (Loc: Bijapur, Rahuri, Parbhani and Solapur)

The trial comprising twenty eight entries were subjected to evaluation for aphids and shoot bug resistance during Rabi 2011-12. The trials were conducted at three test locations (Rahuri, Bijapur, Parbhani and Solapur) for resistance mainly to sugarcane aphid and shoot bug under natural conditions.

Sugarcane aphid (*Melanaphis sacchari*, Zehntner): The colonization of sugarcane aphids (no of aphids/sqcm on 3 leaves) at milky stage was recorded at Solapur and Bijapur. Across the locations, the range was varied from 47.2 to 70.8 aphids on 3 leaves with an average of 58.6 per 3 leaves. Overall all most all the entries were on par with resistant check TAM 428 except SLB 64 and SLR 50. The lowest population was recorded in KR 196 and Long SPS 43. The aphid damage rating (1to 9) was recorded at four locations (Bijapur, Rahuri, Parbhani and Solapur). The damage rating range was from 5.33 to 6.92 being an average rating of 6.21. The entries that recorded damage up to 6 are SLB 50, SLB 79, SLB 80, SLB 83, ICSV 93046, KR 191, KR 196 and long SPS 43 (Table 9.1).

Shoot bug (*Peregrinus maidis*, Ashmead): The data on shoot bug population and damage rating was recorded at Solapur, Bijapur and Parbhani. No shoot bug damage was recorded at Rahuri. The population of adults and nymphs was ranged from 12.3 to 23.0 shoot bugs /plant with an average 17.9 bugs/plant. The low shoot bugs population was recorded on ICSV 93046, SLB 50, SLB 81 and M-35-1. This also confirms with the previous year Rabi 2009-10 results (Table 9.1). It is also indicated that early infestation of shoot bugs at seedling stage may require take an account in the years to come. The damage rating was very low and was ranged from 1.33 to 2.67 in the scale of 1-9 with an average rating of 1.96. No significant differences were observed (Table 9.1).

Days to (50%) flowering: Days to 50 % flowering was recorded at Parbhani and Solapur. Across the locations, the flowering range was 68 to 82 days with an average of 76 days. The entries DJ 6514, SLR 30, SLB 50 recorded early flowering (70 days) and found significant. The entries SLB 79, SLB 83, SLB 10, KR 191 recorded longer flowering (above 79 days) (Table 9.2).

Plant height (cm): Plant height (cm) was observed at Rahuri, Parbhani and Solapur centre. Across the locations, it revealed that the entries SLB 10, TAM 428, KR 191, C 43, SLB 64 and ICSV 745 had less height (108-122 cm). Whereas, SLB 79, SLR 31, SLB 78 and local check recorded 164-183 cm height (Table 9.2).

Grain yield & its components: The grain yield (g/plant) range was varied from 35.3 to 49.4 with an average of 42.5 g/plant. The entries SLB 50, SLB 80, SLB 77, and SLB 31 recorded higher yield > 42g/plant across the locations (Table 9.2).

IV. Screening of initial and advance material for shoot fly and aphids resistance

Trial 10: Screening of advanced lines for shoot fly resistance under diversified conditions (Loc: Solapur). ICAR-ICRISAT collaborations

A trial comprising sixty elite entries including resistant, susceptible and local checks were evaluated for resistance to shoot fly at Solapur under ICSR-ICRISAT collaboration.

Shoot fly (*Atherigona soccata*, Rond): Oviposition preference: The data on seedling infested with shoot fly eggs (%) at 14 DAE was significant and ranged 14.03- 42.62 % with an average of 21.47%. The entries ICSB 433 and 32733 recorded <15% seedling infestation with egg (Table 10.1).

Shoot fly deadhearts at 21 DAE: The data on shoot fly deadhearts at 21 DAE were recorded and was significant at 5% level. The data on deadhearts range varied from 13.57 to 45.38 % with an average of 22.91 %. The entries ICSB 433 and ICSB 431 recorded <15 % deadhearts at 21 DAE and were on par with resistant check (Table 10.1).

Shoot fly deadhearts at 28 DAE: The data on shoot fly deadhearts at 28 DAE were recorded and was significant at 5% level. Overall, the range of shoot fly deadhearts at 28DAE was varied from 29.73 to 75.09% with an average of 44.31%. The entries 32733, ICSB 424, ICSB 433, ICSB 463, ICSB 708, ICSB 717, ICSV 93093, IS 5480, IS 5622 and PS 35805 recorded up to 36.41% DH were on par with resistant check IS 2312 and IS 18551 (Table 10.1).

Morpho-physiological traits: Morpho-physiological traits such as seedling vigor and leaf glossiness have been recorded at and were significant at 5 % level. The range of glossiness was from 2.00 to 5.33 with an average of 3.61. The highest rating (<3) on glossiness was recorded in ICSB 425, ICSB 424, ICSB 428, ICSB 433 ICSB 717, ICSV 93093, PS 35805, ICSB 434, ICSB 461 and ICSV 705. The data on seedling vigor was recorded from 3.67 to 4.33 with an average of 4.03. The entry that recorded up to 3.67 scale are : 90B, 1222B, ICSB 415, ICSB 425, ICSB 428, ICSB 433, ICSB 449, ICSB 459, ICSB 463, ICSV 717, ICSV 93046, ICSV 93093, IS 1054 and IS 5480 (Table 10.1).

Days to 50% flowering : The range was from 69 to 89 with an average of 77 days to flower. Phule Anuradha recorded early flowering (69days) among the entries and the entry RHRB 19 recorded delayed flowering (89 days). The data was significant at 5% level (Table 10.2).

Plant height (cm) at maturity: The data found to be significant at 5% level. The range was 89.17 -245.83 with an average of 164.83. The minimum plant height was recorded in ICSB 458 (89 cm) and the maximum plant height was noticed in M 35-1 x 9808 (246 cm) (Table 10.2).

Grain yield & its components: Grain yield/plant (g) was recorded and was significant at 5% level. The range was from 16 to 60 g/ plant with an average of 34 g/plant. The entries recorded higher grain yield (> 50 g/plant) are IS 1054, ICSV 717, M 35-1 x (Tan Bulk) Phule Anuradha (Table 10.2).

Overall resistant rating (1-9): The data on overall rating on resistance (1-9) for shoot fly and was significant at 5% level. The entries recorded good resistant rating (< 4 rating) are :32745, C 43, CSV 22, ICSB 422, ICSV 705, ICSV 717, IS 2146, IS 5480, M-35-1 (Tank Bulk), Phule Chitra, RSV 1245 and SPV 422. These entries were on par with resistant check (Table 10.2).

Trial 11: Evaluation for Sugarcane Aphid resistance (APH) (Loc: Solapur) ICAR-ICRISAT collaboration

This trial comprising 30 entries evaluated for aphid resistance at Solapur during Rabi 2011-12 under ICAR-ICRISAT collaboration. The trial was planted on 9th November, 2011 to get optimum infestation of aphids.

Sugarcane aphid (Melanaphis sacchari, Zehntner)

Aphid populations (no/cm²/ 3 leaves): The colonization of sugarcane aphids (no of aphids/sqcm on 3 leaves) at milky stage was recorded varied from 32.67 to 117.33 aphids on 3 leaves with an average of 72.89 per 3 leaves and was significant at 5% level. Overall all most all the entries were on par with resistant check TAM 428. The promising entries are: ICSB 724, IS 40615, ICSB 323, RS 29 and ICSR 161. The colonization of sugarcane aphids was recorded at maturity was from 15.00 to 24.67 aphids with an average of 18.43. However the data was not significant at 5% level at maturity stage (Table 11.1).

The aphid damage rating at milky stage (1 to 9) was recorded from 2.00 to 5.33 being an average rating of 3.43. The data was significant at 5% level. The entries that recorded damage up to 2.33 are ICSB 215, ICSB 323, ICSB 695, ICSR 165, 61523, 61588, IS 40617 and Long SPS 43. The data on damage rating (1-9) was recorded at maturity and the range was varied from 2.00 to 8.33 with an average of 4.57. The data was significant at 5% level. The promising entries are: ICSB 323, 61588, ICSB 323, ICSR 165, RS 29, LONG SPS 43 and TAM 428 (Table 11.1).

Days to (50%) flowering: Days to 50 % flowering was varied from 62 to 80 days with an average of 71 days. Hathi Kuntha recorded longer to flower (80 days), whereas, the entry ICSB 215 recorded earliest flowering (62 days). The data was not significant (Table 11.1).

Plant height (cm) at maturity: The data on plant height (cm) was observed and revealed that the entry DSV 5 recorded maximum plant height (192 cm) and the entry CK 60B recorded minimum plant height (83 cm). The data was significant at 5% level (Table 11.1).

Grain yield (kg/ha): Grain yield/plant (g) was recorded and was significant at 5% level. The range was from 472.22 to 2250.00 kg/ha with an average of 1479.01kg/ha. The entries recorded relatively higher grain yield (> 2000 kg/ha) are RSV 1093, RSV 1211, M-35-1 (Table 10.1).

Trial 12: Screening of Germplasm lines for stem borer susceptibility (NGSN-SF)

The un-replicated trial comprised five hundred and three genetic stock and land races (including one resistant check: IS 18551, one susceptible checks: DJ 6514 and one local check: M-35-1) were subjected to preliminary screening for susceptibility to shoot fly at DSR, Hyderabad. Every 20 rows were followed by susceptible check and were planted 15 days before test entry planting. The fish meal was placed as an attractant to ensure optimum level of shoot fly population. About 31 Germplasm lines could germinate at three centers. Overall, the shoot fly deadheart range was 29.09 to 100 % being an average of 44.15%. The data on deadheart % due to shoot fly at 28 DAE are given in Table 12. The lines SEVS -12, EP -80, E - 8, E -92, E -97, PEC -5, PEC -8, NSJB-6562, EG -57, SEB -12002, SEB -12008 and EG -97 had recorded lowest damage (up to 30%).

Less susceptible line to shoot fly (up to 30% DH) at 28 DAE

Particular	
Germplasm screened	500
Not germinated	31
SF DH (%) -Mean	44.15
SF DH (%) -Min	29.09
SF DH (%) -Max	100.00
DJ 6514 (Sus check)	72.41
IS 18551 (Res check)	30.77
M-350-1 (Local check)	41.94
Less susceptible lines (up to 30%)	SEVS - 12, EP - 80, E - 88, E - 92, E - 97, PEC - 5, PEC - 8, NSJB-6562, EG - 57, SEB - 12002, SEB - 12008, EG - 97

V. Management of shoot pests in sorghum through eco-friendly and cost effective approach

Trial 13: Validation of IPM modules for shoot pests in sorghum at Kovilpatti

The trial was planted on 10th October, 2010. A local locally adopted variety K-8 was used with seven treatments in three replications. The data on shoot fly, stem borer damage and midge was significant between the treatments. This is the second year of validation of IPM trial (Table 13).

Shoot fly deadhearts: The deadhearts due to attack of shoot fly was recorded at 28 DAE. The treatment comprising of seed treatment with Imidachloprid 70 WS @ 3 g/kg seed + spray of metasystox @ 0.07% at 45 DAE was superior in terms of reduced damage (5.1% DH) and was on par with Intercropping with legume cowpea) (as per agronomic cropping system recommendations) + seed treatment with Imidachloprid 70 WS @ 3 g/kg seed (6.3 % DH) followed by seed treatment with Imidachloprid 70 WS @ 3 g/kg seed + spray of NSKE @ 5% at 45 DAE (7.3 % DH) and Seed treatment with Imidachloprid 70 WS @ 3 g/kg seed (7.4 % DH). There was marked differences between these treatments over farmers practice (Check) which recorded 17.4 % DH.

Stem borer Leaf injury damage % 45 DAE: Among all the treatments imposed the treatment comprising of seed treatment with Imidachloprid 70 WS @ 3 g/kg seed + spray of metasystox @ 0.07% at 45 DAE was superior in terms of reduced damage (3.7 %). There was marked differences between these treatments over farmers practice (Check) which recorded 19 % damage.

Stem borer Deadhearts (%)-45DAE: The treatment comprising of seed treatment with Imidachloprid 70 WS @ 3 g/kg seed + spray of metasystox @ 0.07% at 45 DAE was superior in terms of reduced damage (3.3% DH) and was significantly superior over other treatments and farmers practice which recorded 8.8 % DH.

Stem and peduncle tunneling: The stem and peduncle tunneling data revealed that seed treatment with Imidachloprid 70 WS @ 3 g/kg seed + spray of metasystox @ 0.07% at 45 DAE was superior in terms of reduced stem tunneling (29.1%) and peduncle tunneling (26.0 %). And was on par with the Intercropping with legume(cowpea) (as per agronomic cropping system recommendations) + seed treatment with Imidachloprid 70 WS @ 3 g/kg seed which recorded 35.7 and 31.4 % stem and peduncle tunneling , respectively. The farmers practice recorded 89.8 and 88.0 % stem and peduncle tunneling.

Midge Spike let damage (%): The treatment comprising seed treatment with Imidachloprid 70 WS @ 3 g/kg seed + spray of metasystox @ 0.07% at 45 DAE was on par with Seed treatment with Imidachloprid 70 WS @ 3 g/kg seed + spray of NSKE @ 5% at 45 DAE, Intercropping with legume(cowpea) (as per agronomic cropping system recommendations) + seed treatment with Imidachloprid 70 WS @ 3 g/kg seed and Seed treatment with Imidachloprid 70 WS @ 3 g/kg seed with less midge spikelet damage over other treatments and farmers practice which recorded 24.2 % midge spikelet damage.

Grain yield (Kh/ha): Treatment comprising of seed treatment with Imidachloprid 70 WS @ 3 g/kg seed + spray of metasystox @ 0.07% at 45 DAE recorded significantly high yield of 4314.3 kh/ha followed by Seed treatment with Imidachloprid 70 WS @ 3 g/kg seed + spray of NSKE @ 5% at 45 DAE (3813.3 kh/ha.). The Intercropping with legume (cowpea) (as per agronomic cropping system recommendations) + seed treatment with Imidachloprid 70 WS @ 3 g/kg seed recorded 3180.3 kg/ha yield. The farmers practice realized yield of 3114.7 kg/ha.

Overall, the Intercropping with legume(cowpea) (as per agronomic cropping system recommendations) + seed treatment with Imidachloprid 70 WS @ 3 g/kg seed was viable option considering the on par damages with treatment comprising of seed treatment with Imidachloprid 70 WS @ 3 g/kg seed + spray of metasystox @ 0.07% at 45 DAE and use of minimum inputs and additional yield of legumes.

Table 13. Validation of IPM module during Rabi 2011-12 at Kovilpatti

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 ,

Cultivars used: Sorghum- K-8,

Cowpea: Local variety

S No.	Treatment	Shoot fly DH (%) - 28DAE	Stem borer Leaf injury damage % 45 DAE	Stem borer Leaf injury damage rating	Stem borer DH (%) - 45DAE	Stem borer - stem tunneling (%)	Stem borer - peduncle tunneling (%)	Midge Spike let damage (%)	Grain yield Kg/ha
1	Commercial cultivar K-8 (without treatment)	15.0	16.9	2.0	8.2	94.8	92.3	20.6	2835.7
2	Seed treatment with Imidachloprid 70 WS @ 3 g/kg seed	7.4	9.4	1.3	4.6	35.4	42.0	13.2	3155.0
3	Intercropping with legume (cowpea) without any treatment (as per agronomic cropping system recommendations)	11.4	14.8	2.0	5.9	59.4	55.4	15.5	3051.7
4	Intercropping with legume(cowpea) (as per agronomic cropping system recommendations) + seed treatment with Imidachloprid 70 WS @ 3 g/kg seed	6.3	7.9	1.0	4.7	35.7	31.4	12.5	3180.3
5	Seed treatment with Imidachloprid 70 WS @ 3 g/kg seed + spray of NSKE @ 5% at 45 DAE	7.3	6.1	1.0	5.4	44.8	28.5	12.0	3813.3
6	Seed treatment with Imidachloprid 70 WS @ 3 g/kg seed + spray of metasystox @ 0.07% at 45 DAE	5.1	3.7	1.0	3.3	29.1	26.0	10.9	4314.3
7	Farmers practice (check)	17.4	19.0	2.3	8.8	89.8	88.0	24.2	3114.7
	CD (0.05)	2.1	1.7	0.6	1.2	8.7	7.8	3.0	496.3
	CV	11.9	8.7	21.1	11.3	8.8	8.5	10.7	8.3

Trial 14: Testing of organic IPM modules for shoot pests in sorghum at Bijapur

An IPM trial comprising of organic farming (use of vermicompost, neem cake application) was conducted at this center. The trial was replicated thrice. CSV 216R was a commercial variety was used. The plot size was (6 rows of 5 m= 18 sqm) at 60 cm apart as row distance. The net plot was harvested (11.28 sqm). The data on shoot fly, aphid index shoot bug was recorded (Table 13).

Table 14. Validation of IPM module during Rabi 2011-12 at Bijapur

Year / Season / Location: 2011-12

Rabi:

RARS, Bijapur, Karnataka

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 % (28 DAE)	% Aphid index (80 DAE)	Shoot bug population / 5P	Mean SPAD reading	Grain yield (kg/ha)	Fodder yield (kg/ha)
T ₁	Application of Vermicompost @ 7.5 q/ha	18.3	44.1	49.4	56.4	1403.33	2420.00
T ₂	Application of deoiled Neem cake @ 6.25 q/ha	16.4	37.4	52.3	52.8	1420.00	2510.00
T ₃	Application of Vermicompost(50%) + deoiled Neem cake(50%) @ 3.75 + 3.12q/ha	21.8	29.2	38.2	54.5	1553.33	2603.33
T ₄	Application of Vermicompost @ 7.5 q/ha + 50% RDF	19.6	59.8	54.2	52.4	1486.67	2583.33
T ₅	Application of oiled Neem cake @ 6.25 q/ha + 50 % RDF	16.4	58	54.0	49.3	1456.67	2610.00
T ₆	100 % RDF	24.5	80.5	75.8	49.1	1550.00	2713.33
T ₇	Untreated check	25.5	78.1	76.9	43.7	1120.00	2040.00
	CD (0.05)	2.8	7.2	5.1	4.7	65.28	303.61
	CV (%)	7.7	7.3	4.9	5.3	2.58	6.84

Shoot fly deadhearts (28 DAE): The shoot fly infestation was significantly low in treatments comprising of Application of deoiled Neem cake @ 6.25 q/ha (16.4 % DH), Application of oiled Neem cake @ 6.25 q/ha + 50 % RDF (16.4 % DH) and Application of Vermicompost @ 7.5 q/ha (18.3 % DH) and they were on par with each other and significantly superior over control which recorded 25.5% DH. Application of Vermicompost (50%) + oiled Neem cake (50%) @ 3.75 + 3.12q/ha and Application of Vermicompost @ 7.5 q/ha + 50% RDF were on par with each other. There was no difference in shoot fly infestation in control and at 100 % RDF.

Aphid index (80 DAE):The treatments comprising of application of Vermi-compost(50%) + oiled Neem cake(50%) @ 3.75 + 3.12q/ha and Application of deoiled Neem cake @ 6.25 q/ha recorded low aphid index 29.2 and 37.4 %, respectively they were on par with each other and significantly superior over other treatments and control. Treatment comprising 100% RDF (80.5%) and untreated check (78.1%) recorded high aphid indexes.

Shoot bug population: Application of Vermicompost(50%) + deoiled Neem cake(50%) @ 3.75 + 3.12q/ha resulted in significantly low shoot bug population/ 5 plants (38.2nos) compared to other treatments and control (76.9 nos.)

Grain and fodder yield (kg/ha): The application of Vermi-compost (50%) + deoiled Neem cake (50%) @ 3.75 + 3.12q/ha recorded highest grain yield (1553.33 kg/ha), followed by the application of 100% RDF (1550.00 kg/ha). Both the applications were superior to untreated check. Whereas, all treatments except untreated check were on par with each other and recorded fodder yield in the range of 2420 to 2713 kg/ha. The application of 100 % RDF recorded highest fodder yield (2713.33 kg/ha). Over all application of Vermi-compost (50%) + deoiled Neem cake (50%) @ 3.75 + 3.12q/ha was the best treatment. Since this is first year of trial it needs to be validated during next season to draw conclusions.

Trial 15: Testing of IPM module on farmer's field in sorghum at Parbhani

An IPM module on farmer's field was tested at Purna, Dist. Parbhani. Sowing was done in second week of July. IPM plot recorded 5.75 q/ha grain yield and 21 q/ha fodder yield. Non IPM plot recorded 4.6 q/ha grain yield & 18 q/ha of fodder yield. IPM plot recorded 25% increase in grain yield over non-IPM (no-seed treatment) and 16% increase in fodder yield.

Table 15. Validation of IPM module on farmers' field during -2011-12 at Parbhani

Year / Season / Location: Purna, District: Parbhani Maharashtra

Plot size: 1 acre each, Treatment 02= 1). Seed treatment 2) No seed treatment

Particulars	IPM Plot	Non IPM Plot
Treatment	Seed treatment with thiamethoxam 35 FS @ 6ml/kg	No seed treatment
Location	Purna, District : Parbhani	Purna, District : Parbhani
Variety	PKV 809	PKV 809
Grain Yield (q /ha)	5.75 (25% increase)	4.60
Fodder Yield (q /ha)	21.0 (16 % increase)	18.00

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
2	Dr Kavitha Sorghum Entomologist	ARS, Palem, Dist : Mahaboobnagar, Andhra Pradesh	palem@sorghum.res.in kaviangrau@gmail.com
3	Dr Shekharappa Principal Entomologist	ARS, UAS, Dharwad, Karnataka	shekhar1993@yahoo.com, dharwad@sorghum.res.in
4	Dr AP Biradar Principal Entomologist	RARS, UAS, Bijapur, Karnataka	bijapur@sorghum.res.in, apbiradar123@rediffmail.com
5	Dr DB Pawar Sorghum Entomologist	Sorghum Improvement Project, MPKV, Rahuri	rahuri@sorghum.res.in
6	Dr DG Daware Principal Entomologist	MAU, Parbhani, Maharashtra	parbhani@sorghum.res.in
7	Dr HC Sharma Principal Entomologist	ICRISAT, Patancheru, Andhra Pradesh	h.sharma@cgiar.org
8	Dr Prabhakar Principal Breeder	CRS, Solapur, Maharashtra	prabhakar@sorghum.res.in
9	Dr A Srinivas Babu Sorghum Entomologist	DSR, Rajendranagar, Hyderabad-500030 (AP)	sbabu@sorghum.res.in
10	Dr G Shyam Prasad Principal Entomologist	DSR, Rajendranagar, Hyderabad-500030 (AP)	shyam@sorghum.res.in
11	Dr VR Bhagwat, Principal Scientist (Entomology) & Convener	DSR, Rajendranagar, Hyderabad-500030 (AP)	bhagwat@sorghum.res.in

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
1	Kovilpatti	7	15-10	NR	R	R	NR	NR
2	Bijapur	7	17-10	R	R	R	R	R
3	Dharwad	8	15-10	R	R	NR	NR	NR
4	Tandur	5	16-10	R	R	NR	NR	NR
5	Rahuri	9	04-10	R	NR	R	R	R
6	Parbhani	9	02-11	R	R	R	R	R
7	Solapur	9	15-10	R	R	NR	NR	R

R= Received; NR = Not Recorded

Annexure-III: Summary of trials allotted to AICSIP

Trial No	Name of Trial	Entries x Reps	Rows x 2m	Centers								
				Kovi	Bija	Dhar	Tand	Rahu	Parb	Sola	Hyd	Tot
1	AVHT-DS	20 x 3	2 x 2	1	1	1	1	1	1	1	1	7
2	AVHT-SS	18 x 3	2 x 2	1	1	1	1	1	1	1	1	7
3	IVHT-DS	27 x 3	2 x 2	1	1	1	1	1	1	1	1	7
4	IVHT-SS	22 x 3	2 x 2	1		1	1	1	1	1	1	6
5	SFR (F5) lines (single plant)	32 x 3	2 x 2					1	1		1	3
6	Local checks for SF-SB	12 x 3	2 x 2	1	1	1				1		4
7	B & R lines-SF	25 x 3	2 x 2			1		1		1		3
8	ASFN	20 x 3	2 x 2			1		1	1		1	4
9	Aphid and shoot bug Nursery (APSHN)	28 x 3	2 x 2		1			1	1		1	4
10	Evaluation for shoot fly resistance (ICRISAT collab)	60 x 3	2 x 2							1		1
11	Evaluation for Aphid resistance (ICRISAT collab)	30 x 3	2 x 2							1		1
12	IPM/organic	7 x 3	18 x 7	1	1				1			3
13	Pest survey & surveillance in farmer' field			1	1	1	1	1	1	1		7
Total Trials conducted				7	7	8	5	9	9	9	3	57
		Sowing date		15 Oct	17 Oct		16 Oct	4 Oct	2 Oct	15 Oct		
		Local check used		K-8	DSV 4	DSV4	M-35-1	Phule Vasudha	Parbhani Moti	M-35-1	M-35-1	

Annexure-IV: Parameters for insect pest resistance used for recording observations

Pest	Crop age (days)	Resistance parameters
Shoot fly	14 & 21	No. of seedlings with eggs
	14 & 21	No. of eggs / 10 seedlings
	21 & 28	Deadhearts (%)
Stem borer	30 & 45	Leaf feeding score (1-9) (1= low ; 9 = high)
	30 & 45	Leaf injured plants (%)
	30 & 45	Deadheart (%)
	Before harvest	No. of chaffy/broken panicles
	At harvest	No of productive panicles
Sugarcane aphid	30,45 & 60	Population density rating (1-9) (1= low; 9 = high)
	30,45 & 60	Plant damage rating (1-9) (1= low; 9 = high) (Based on necrosis/sooty molds)
Shoot bug	30,45 & 60	Population density rating (1-9) (1= low; 9 = high)
	45,60 & 75	Plant damage rating (1-9) (1= low; 9 = high)
	After harvest	Grain yield/plant (g)
Sorghum midge	At spikelet stage	Midge damage (%)
	At milk stage	Plant damage rating (1-9) (1= low; 9 = high)
Ear head bug	At flowering	Head bug population/plant
	At milky stage	Head bug population/plant
	At milky stage	Head panicle damage rating 1-9) (1= low; 9 = high)

Annexure-V: 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