

6. Sorghum Entomology

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VR Bhagwat, G Shyam Prasad, V Rajaram, K Kavita, Shekharappa, DG Daware, HG Kandalkar,
SN Upadhyay, JR Uttam, T Hussain and NB Rote

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Summary

1. Evaluation of grain sorghum experimental varieties/ hybrids/ parental lines for resistance to key insect pests

a) Shoot fly - Deadhearts (%)

1. None of varieties/hybrids found better than resistant check IS 2312 as shoot fly resistant source in AVHT I, II, III, AHT and AVT trials at 5% level. Interestingly, the local checks CSV 17 in AVHT-I and Mauti in AVHT-III found comparable with resistant check at 1% level.
2. In AVHT (DP) trial, SPV 1754, SPV 1616, SPV 1779, and local check found less attacked by shoot fly and at par with IS 2205 at 1% level. In case of IVT (DP), SPV 1822, SPV 1616, CSV 15 and SPV 1825 equally good as IS 2205 at 5% level.
3. In shoot fly nursery (SFN), the entries SUENT 12, SUENT 13, SUENT 14, SUENT 15, NRCSFR07-4, NRCSFR07-5 found less attacked by shoot fly and comparable with IS 2312.
4. The sweet sorghum varieties and hybrids that showed less susceptibility toward shoot fly are: SPSSV 4 and CSV 19SS.
5. MAS for shoot fly resistance lines: MAS 1062-3, MAS 1062-6, MAS 1076-1, MAS 1261-3 showed <55 % deadhearts. In another set of trial, RSFO51 (7B)-1S, RSFO51 (7C)-6S, RGF 123051(29B)-101S, RGF103054 (26A)-022S found below 38% deadhearts. RSFO51 (7C)-6S recorded lowest deadhearts and found better than check IS 2312 and IS 18551.

b) Stem borer –Deadhearts (%)

1. The stem borer deadhearts was ranged from 3.0 to 26.3% in all trials.
2. Some of the lines have shown reasonably low incidence of stem borer and comparable with resistant check IS 2205.

- The lines performed better are: CSH 23, SPV 462, CSV 17, CSH 16, SPV 1616, SPV 1746 and SPV 1730 in AVHTs. Similarly SPV 462, CSV 15, SPV 1821 CSH 16, SPH 1617, SPH 1606 in IVHTs found better.
- The entries: SPV 1750, SPV 1616, SPV 1779 in AVHT (DP) and SPV 1823, SPV 1616, local check in IVT (DP) found resistance sources for stem borer.
- In sweet sorghum trial the entries: SPSSV 20, SPSSV 27 are comparable with ICSV 714 a resistant check for stem borer.

c) Midge- spikelet damage (%)

- In general, the hybrid recorded higher spikelet damage than varieties.
- The entries that recorded < 20% spikelet damage are: CSH 23, SPV 1600, CSV 17, SPH 1567, SPV 462, SPV 1746, SPH 1342 and SPH 1587 in AVHTs.
- The entries SPV 1814, SPV 1819, SPV 1827, SPV 1813, CSH 16, SPH 1607, local check in AVT/AHT recorded low spikelet damage (<18%).
- In AVHT (DP), the entries SPV 1778, CSH 18 and In IVT (DP) only one entry SPV 1824 recorded <15 % spikelet damage.

d) Head bug (no/panicle)

- The head bug population was moderate (>25 nos/ panicle) in AVHTs. The entries shown <10 head bugs/panicle are: CSV 17, SPV 1774, SPV 1775, Local check, CSH 23, SPV 1746, CSH 16 and CSV 17 in AVHTs.
- In AVT/AHT the entries: CSH 16, CSV 17, SPV 1746, SPH 1607, SPH 1617 showed <10 head bugs/panicle.
- In AVHT and IVT (DP), the bug populations were low (<22 nos/panicle). The entries IS 1753, local check, SPV 1750, CSV 15, CSH 18 and in IVT: SPV 1821, SPV 1826 and SPV 1824 recorded <10 bugs/panicle.

e) Shoot bug-Plant damage (%)

- The maximum plant damage (15%) was recorded in susceptible entries.
- The entries shown < 8% damage are: SPH 1567, SPV 1616, SPV 1774, SPV 1811, SPV 1813, SPV 462, SPH 1603, SPH 1604, SPH 1610, SPH 1611, SPH 1615 and CSH 23 mostly in AVHT-II, IVT and IHT trials.

2. Development of new sources for multiple resistant

- Interdisciplinary trial was conducted at Dharwad, Parbhani and Udaipur by entomologist and Pathologist to identify multiple resistant lines for pest and disease.
- One line NRCSFR06-1 was identified as multiple resistant source to shoot fly, stem borer, foliar diseases viz., rust, zonate leaf spot, target leaf spot and downy mildew.

Table 1: Promising resistant source for shoot fly Kharif 2007

Trial	Promising lines for shoot fly resistance	DH % in selected lines	Resistant check* (DH %)	Susceptible check** (DH %)	Mean (DH %)	Remarks
AVHT-I	SPV 1774, SPV 1733, CSV 17	< 30	10.1	87.6	34.7	CSV 17 showed promise at 1%.
AVHT-II	CSV 15, Local check	< 35	16.6	87.7	42.7	Not better than check at 1 % level.
AVHT-III	Local check	< 32	15.4	86.3	37.8	Local check had low DH% at 1%.
AVHT (Dual)	Local check, SPV 1779, SPV 1754, SPV 1616	< 40	17.2 (IS 2205)	80.6	39.7	Local check low at 5%. Others entries at 1%.
IVT (Dual)	CSV 15, Local check, SPV 1822, SPV 1616, SPV 1825	< 40	15.9 (IS 2205)	83.9	37.0	Equally good at 5%, comparable with resistant check
ASSVHT	SPSSV 4, CSV 19SS	< 36	21.4 (IS 2205)	52.4	42.6	Less susceptible, at par with check at 5%.
MAS-SF-I	MAS 1062-3, MAS 1062-6, MAS 1076-1, MAS 1261-3	< 55	45.5	79.9	62.8	Low deadhearts and comparable with check
MAS-SF-II	RSF051(7B)-1S, RSF051 (7C)-6S, RGF 123051(29B)-101S, RGF103054 (26A)022S	<38	34.3	79.2	45.3	Least deadhearts and at par with resistant check at 5 %
SFN	SUENT 12, SUENT 13, SUENT 14, SUENT 15, NRCSFR07-4, NRCSFR07-5	< 34	15.6	73.9	37.1	Low deadhearts % and equally good, compared to check.
PDRN	SUENT 9, SUENT 8, NRCSFR06-1, NRCSFR06-2, local check	< 35	17.5	91.1	45.6	NRCSFR06-1 -source for multiple resistant.

* = Resistant check: IS 2312, ** = susceptible check: DJ 6514

Table 2: Promising resistant source for stem borer -Kharif 2007

Trial	Promising lines for stem borer resistance	DH % in selected lines	Resistant check* (DH %)	Susceptible check** (DH %)	Mean (DH %)	Remarks
AVHT-I	CSH 23, SPV 462, CSV 17	< 10	8.1	26.3	12.8	Less susceptible lines to stem borer.
AVHT-II	CSH 16, SPV 1616, SPV 1746	< 11	8.9	22.4	12.4	All lines had less stem borer.
AVHT-III	CSV 17, local check, CSV 17, CSH 16, SPV 1730	<12	6.1	24.6	13.9	All lines except few performed well.
IVT	SPV 462, CSV 15, SPV 1821	<10	8.1	19.4	11.5	These lines are topper after resistant check.
IHT	CSH 16, SPH 1617, SPH 1606	<9	7.2	17.1	9.9	All lines have shown less damage except susceptible check.
AVHT (Dual)	SPV 1750, SPV 1616, SPV 1779	<10	5.9	14.9	10.0	All lines except few performed well
IVT (Dual)	SPV 1823, SPV 1616, local check	<10	6.4	17.1	10.3	Equally good at 5%, comparable with resistant check
ASSVHT	SPSSV 20, SPSSV 27	< 11	3.0 (ICSV 714)	12.0	14.9	Less susceptible, at par with check.
PDRN	GMRP 112, GMRP 96 NRCSFR06-1, SUENT 9	< 6	4.1 (IS 2312)	8.2 (GMRP 109)	6.1	Low infestation.

* = Resistant check: IS 2205, ** = susceptible check: DJ 6514

Table 3: Promising entries with less susceptibility to other key pests of grain and dual-purpose sorghum from different trials, Kharif- 2007 (Location: 09)

Trial	Midge (spikelet damage %)		Head bug (no/panicle)		Shoot bug (Plant damage %)	
	Promising lines	Damage %	Promising lines	no/ panicle	Promising lines	Damage %
AVHT-I	CSH 23, SPV 1600, CSV 17	< 20	CSV 17, SPV 1774, SPV 1775, Local check, CSH 23	10	-	
AVHT-II	SPH 1567, SPV 462, SPV 1746	>15	CSV 17, SPV 1746	10	SPH 1567, SPV 1616, SPV 1774	>8%
AVHT-III	CSV 17, SPH 1342, SPH 1587	>15	CSH 16, CSV 17, SPV 1746	10		
IVT	IS 1814, SPV 1819, SPV 1827, SPV 1813	>15	SPV 1809, SPV 1810, SPV 1821	10	SPV 1811, SPV 1813, SPV 462	>8%
IHT	CSH 16, SPH 1607, local check	>18	SPH 1607, SPH 1617	13	SPH 1603, SPH 1604, SPH 1610, SPH 1611, SPH 1615, CSH 23	>8%
AVHT (Dual)	SPV 1778, CSH 18	>15	IS 1753, local check, SPV 1750, CSV 15, CSH 18	10		
IVT (Dual)	SPV 1824	>15	SPV 1821, SPV 1826, SPV 1824	5		

3. Development of new sources of resistance for genetic diversity

1. A set of 14 F₂ and F₃ crosses was evaluated for shoot fly resistant at Hyderabad, Akola and Udaipur. Another set of 8 crosses was screened for stem borer resistance at Warangal, Indore and Surat.
2. About 88 plants from seven progenies (Hyderabad), 71 plants from nine progenies (Akola) and 8 plants from two progenies (Udaipur) were selected for shoot fly.
3. Similarly, 62 plants from 8 progenies (Warangal), 34 plants from one progeny (Indore) and 58 plants from 8 progenies (Surat) were selected and will be used for further evaluation.

4. Validation of IPM modules for shoot pests

1. Seed treatment for sole grown sorghum with Thiamethoxam 70 WS @t 3 g/kg seed followed by either one spray of endosulfan 35EC (0.07%) or NSKE (5%) at 45 DAE reduced the shoot fly and stem borer damage significantly.
2. When treated sorghum (Thiamethoxam 70 WS @t 3 g/kg seed) was intercropped either with redgram, soybean or moong found to be effective in reducing shoot fly and stem borer damage and identified as profitable model of IPM in terms of monetary gain.

Sorghum entomology report

I. Evaluation of grain sorghum experimental varieties/ hybrids/ parental lines for resistance to key insect pests

Advance Varietal and Hybrid Trial (AVHT)

Three trials namely AVHT-I, AVHT-II and AVHT- III were conducted across the zones for evaluating resistance to key pests.

Trial 1: Advance Varietal and Hybrid Trial-I (AVHT-I): Under AVHT-I, 18 experimental varieties and hybrids, one local check, two resistant checks and one susceptible check were evaluated at nine locations (Palem and Coimbatore in Zone I; Dharwad, Akola, Indore and Surat in Zone II; and Kanpur and Udaipur in Zone III) for resistance to major pests. Parbhani centre did not plant the material.

Shoot fly: Deadhearts caused by the shoot fly was recorded at 14, 21 and 28 Days after emergence (DAE). Deadhearts caused by the shoot fly was recorded at 28 DAE at eight locations (Palem and Coimbatore in Zone I; Dharwad, Akola, Indore and Surat in Zone II; and Kanpur and Udaipur in Zone III (Table 1.1). The data from Indore and Kanpur was rejected due to high CV (> 30%). The trial consisted of 13 varieties, 5 hybrids, one local check, 2 resistant checks and one susceptible check. At Palem, the entries SPV 1775, SPV 1774, SPV 1746, CSV 17, SPV 1696 and SPV 462 recorded significantly low shoot fly damage at 28 DAE (20.3 - 27.7% DH) and were on par with resistant checks (IS 2312 and IS 2205). The mean damage was 30.8% and damage ranged from 14.4 - 48.5%. The deadheart at Coimbatore ranged from 0-44.4%. The entries SPV 1775 (7.7%) and SPV 1630 (9.1%) were superior among test entries however they were not on par with resistant checks. At Akola none of the test entry was on par with the resistant checks. The entries SPV 1616, SPV 1774, SPV 462, CSH 23, SPV 1630, SPV 1775, SPV 1696, SPV 1600, CSH 18, SPV 1742, CSV 17, SPV 1733 and CSV 15 recorded low deadhearts (30 - 40%) and were superior next to checks in terms of shoot fly damage. The mean shoot fly damage was 39.3% and damage ranged from 10 - 59.7%. At Dharwad, the entry SPV 1746 was significantly superior (38.2% DH) and was on par with resistant check IS 2205 (22.1%) and inferior to IS 2312 (RC). The damage ranged from 16 - 95.5%, the average being 57.8%. Among the test entries, SPV 462, SPV 1774, SPV 1630, SPV 1616 and CSV 17 were significantly superior (21.9 - 26.2% DH) and on par with resistant checks. The mean damage was 31.7% and damage ranged from 25 - 80%. At Udaipur (Zone - III), the entry CSH 18 recorded significantly lowest deadhearts (17.9%) and was on par with resistant check IS 2205, but inferior to IS 2312 (Resistant check). The mean damage was 9.7%, range being 4.3 - 88.6%. Across the locations and zones, the mean shoot fly deadheart formation was 34.7%, range being 10.1 - 87.6%. The entry CSV 17 was significantly superior among all entries and was on par with IS 2205 and inferior to IS 2312 at 5% LSD.

Morpho-physiological traits: Other morpho-physiological traits such as seedling vigor, leaf glossiness and seedling height have not been recorded in any of the centres during Kharif 2007. However, oviposition was recorded at Palem, Dharwad and Surat. Heavy oviposition was observed in Palem. The least preferred entries were SPV 1746, CSV 15 and SPV 1775 (Table 1.2).

Spotted stem borer: The data on spotted stem borer infestation was assessed in terms of leaf injury plants (%) at 30 DAE, deadhearts (%) at 45 DAE, stem tunneling (%) and peduncle damaged plants (%). The data on percent leaf damage plant was recorded at 30 DAE at Palem and Coimbatore in Zone I, Akola, Indore, Surat in zone II and Udaipur in zone III. The data from centres recorded high CV in Palem and Indore. Susceptible check recorded low level of percent leaf damage (>70%). Overall, CSH 23, CSV 17 and local check showed lower leaf damaged plants due to stem borer (Table 1.4).

The data on dead hearts at 45 DAE was recorded at Palem, Coimbatore, Indore, Surat, Kanpur and Udaipur. The data from Indore and Kanpur had to be ignored due to high CV. In zone-I, CSV 17, SPV 462, CSH 16, SPV 1596 SPV 1733 and local check recorded less damage and comparable with resistant check. In Zone-II, CSH 16, CSH 23, SPV 1742 and CSV 17 noted less damage. In Zone -III, SPV 1775, SPV 1616, CSH 23, SPV 1600 found relatively better than other test entries. CSH 23, SPV 462 and CSV 17 were best across the locations (Table 1.3). The data on stem and peduncle tunneling due to stem borer was recorded at Coimbatore centre only. Least stem tunneling (%) was recorded in SPV 1774, SPV 1616, CSV 15 and SPV 1577 and comparable with resistant check IS 2205 (Table 1.2). The data on peduncle tunneling (%) was recorded at Coimbatore. Significantly a low peduncle damage percentage plant was recorded in SPV 1733, SPV 462 and SPV 1577 (Table 1.2).

The peduncle damage plants (%) were recorded in Palem, Coimbatore, Akola and Dharwad. The least damage was recorded in DJ 6514 and followed by SPV 1775, SPV 1742, local check and SPV 1630 in Zone-I. While in Zone -II, the least damage was recorded in SPV 1600 and followed by SPV 462, SPV 1742, IS 2312 and IS 2205. Overall, DJ 6514 recorded least peduncle damage due to stem borer and followed by SPV 1742, SPV 1775 and local check (Table 1.5).

Midge: Spike let damage due to midge was recorded at Coimbatore and Dharwad centre only. The entries CSH 23, CSV17, SPV 1600, SPV1696 and DJ 6514 recorded significantly low spike let damage percentage (Table 1.2). Panicle damage was recorded at Coimbatore only. Least damage rating was noticed in DJ 6514, CSV 17, IS 2312, IS 2205 and CSH 23 (Table 1.3).

Head bug : Head bug population density at flowering was recorded at Palem, Coimbatore and Indore. The population colonization of head bugs was significantly low on CSV 17, CSH 23, SPV 1774, SPV 1775 and IS 2312 (Table 1.6). The Panicle damage due to head bug was recorded in the scale of 1 to 9 at Palem and Coimbatore. The panicle damage rating was relatively higher at Coimbatore than Palem. The entries CSH 23, CSV 17, SPV 1775 and CSH 16 recorded least peduncle damage rating not more than < 2.3 (Table 1.6).

Days to 50 % flowering: Days to 50% flowering were recorded at Dharwad and Surat. Among the entire test entries, CSV 17 showed early flowering followed by SPV 1696, CSH 23 and SPV 1630 (Table 1.4).

Grain yield & its components: Grain yield in grams per plant was assessed at Surat and Udaipur. When all the entries were exposed to all biotic stresses, especially insects, the grain yield plant⁻¹ was recorded for all the test entries mentioned above. Among the test locations, mean higher grain yield was recorded at Udaipur centre. The test entries SPV 1775, SPV 1596, SPV 1733, SPH 1577 and SPV 1616 registered higher grain yield plant⁻¹ compared to all other test entries across the locations (Table 1.5).

Trial 2. Advance Varietal and Hybrid Trial-II (AVHT-II, Zone II): Under AVHT-II, 14 experimental lines, two resistant (IS 2312, IS 2205), one local check and one susceptible (DJ 6514) were evaluated at nine locations (Palem, Coimbatore in Zone I; Parbhani, Dharwad, Akola, Indore, Surat in Zone II; and Kanpur, Udaipur in Zone III) for resistance to major pests.

Shoot fly: Deadhearts caused by the shoot fly was recorded at 14, 21 and 28 DAE. However, most of the centres have recorded the data at 28 DAE. The data on shoot fly deadhearts was recorded at 28 DAE at Palem, Coimbatore (Zone I), Parbhani, Akola, Dharwad, Indore, Surat (Zone II) and Kanpur, Udaipur (Zone III). The data on deadhearts formation at 28 days after emergence showed high CV (>30 %) in Indore, Kanpur and Udaipur centres. Due to low deadhearts formation (<70%) in the susceptible check (DJ 6514) in Coimbatore, Akola, and Kanpur could not considered either for zones or all-India averages.

Shoot fly deadhearts: The deadhearts caused by shoot fly was recorded at 28 DAE at all the locations. At Palem the damage ranged from 26.7-86.1%. The mean damage was 47.6%. The entries local check, SPV 1616 and SPV 1786 recorded significantly lowest deadhearts (7.1 - 37.1%) and were on par with resistant check IS 2312. At Coimbatore, the entries local check and CSH 23 recorded significantly lower damage and were significantly different from resistant checks. The CV was exceptionally low (9.6%). Across the locations of Zone - I the entries local check, SPV 1616 and SPV 1786 recorded lowest deadhearts and were on par with resistant check IS 2312 and IS 2205.

In zone- II, Parbhani, the damage due to shoot fly ranged from 12 - 91.6%, the average was 45%. The entries, CSH 18, local check, SPV 462, SPV 1616, CSV 15, SPV 1600, SPV 1774, SPV 1786 and CSV 17 recorded lower deadhearts (34.4 - 49.1% at 28 DAE. These entries were significantly different to resistant checks IS 2312 and IS 2205, which recorded 12 and 14.2 % DH. At Akola, the shoot fly damage ranged from 9.7 - 60.3%. None of the entries were on par to resistant check. At Dharwad, the damage ranged from 24.8 - 89.5% and average damage was 60.5%. Among the entries CSV 15, SPV 1746, Local check and SPV 1786 recorded significantly low deadhearts (38.5 - 48.8%DH) at 28 DAE and were on par with resistant checks. The mean damage at Surat was 40.9% and damage ranged from 21.9 - 82.8%. The entries SPV 1616, SPV 1774, CSV 17 and SPV 462 recorded significantly low deadhearts (27.2 - 36.3%) and were on par to resistant checks.

In Zone III only data from Udaipur was considered. The entries SPV 1616 (15.7% DH) and CSV 15 (16.1% DH) were significantly superior and on par with resistant checks.

Across the zones and locations, none of the entries were on par with resistant checks (IS 2312 and IS 2205). The entries CSV 15, local check, SPV 1616, SPV 1786, SPV 462, CSV 17, SPV 1774, SPV 1746, CSH 23 and SPV 1742 were promising lines recording low deadhearts (33.8 - 43.8% DH at 28 DAE). Shoot fly eggs/10 plants from Parbhani, Dharwad and Surat could not be considered due to high CV (> 30%). At Palem, the oviposition ranged from 7.7–16 eggs/10 seedlings with average of 13.2 eggs on 10 plants. The entries CSH 18, SPV 1746, SPH 1567, CSH 16, SPV 1742, local check, CSV 15 and SPV 1600 recorded significantly lower eggs (Table. 2.2).

Stem borer: At Coimbatore the tunneling of stem and peduncle was recorded. Among the entries CSV 15, SPV 462 recorded least damage and were on par with resistant check (Table 2.2). The data on stem borer deadhearts from Palem, Coimbatore, Parbhani, Indore, Udaipur could not be considered due to exceptionally high CV (>35%). At Surat, SPV 1616, Local check, CSH 18, CSH 16, CSH 23 were tolerant recording (20.4 – 23% dead hearts. In zone II across the locations CSH16, SPV 1616, CSV 15, local check, SPV 1746 recorded least damage by borer (10.1 – 13.4% dead hearts at 45 DAE. At Kanpur, the entries SPV 1600, CSH 23, SPV 1786, SPV 1746, CSV 17, CSV 15 recorded least deadhearts. Across the zones, the entries CSH 16, SPV 1616, SPV 1746, SPH 1567 and CSV 15 were best and ranged of deadhearts was from 9.2 to 10.8% at 45 DAE (Table 2.3).

In Zone I, the data on leaf injury on plants due to stem borer from Palem was ignored due to exceptionally high CV (> 30%). At Coimbatore the damage ranged from 0-26.6%. The entries CHS 16 and local check (CO-28) were superior with 3.7 and 5.0% damage.

In Zone- II the data from Parbhani, Indore could not be considered due to exceptionally high CV. At Akola, the leaf injury by stem borer ranged from 23-57.3%. Among the entries local check (SPH 840), CSH 16, SPV 1746, CSH 16, CSV 17, SPH 1567 and SPV 1786 were statistically on par with resistant check IS 2205. At Surat, the damage ranged from 22.3-53.2%. The entries SPV 1786, CSH 23 were statistically on par with resistant check IS 2205.

At Udaipur (Zone – III), the entries SPV 1786, CSH 16, SPV 1616, SPV 462, CSV 15, CSV 17, local check (CSV 17), SPV 600, SPV 1746, SPV 1742, CSH 18 were on par with resistant check. There was low level of leaf injury on plants. Across the zones, the leaf injury damage ranged from 14.1 – 21.1%, with mean of 17.7%. The entries, local checks, SPV 1786, CSH 16, CSV 15 and SPV 1742 recorded lower leaf injuries due to stem borer (Table 2.4).

The data on stem borer peduncle damage plants (%) was recorded at Palem. Akola had to be rejected due to high CV. At Coimbatore (Zone-I), the damage ranged from 28.3 – 49.4%. The entries SPV 462, local check (CO-28) was statistically on par with resistant checks. At Dharwad (Zone-II), the damage ranged from 12.8 – 31.5%, the mean being 12.8%. The entries, SPV 1616, SPV 1786, SPV 1746, CSH 18, CSV 15, local check, CSH 16, SPH 1567, SPV 1774 were on par with the resistant checks. Across the zones, the peduncle damage ranged from 17.3 – 31.1%, the mean was 22.4%. The entries local check, CSH 16, SPV 462, CSH 18, SPH 1567 recorded least damages by borer (Table 2.5).

Midge: The midge panicle damage rating (1-9) was recorded at Coimbatore only. The entries SPV 1742, SPV 1746, local check (CO-28), CSV 15, SPV 462, SPV 1616, SPH 1567, SPV 1786 recorded least score between 0.98 to 1.97 (Table 2.3).

The damage of midge on spikelet was recorded at two centers, Coimbatore and Dharwad. At Coimbatore the midge damage ranged from 2.3 – 16.3%. The entries SPV 1742, SPV 462 were statistically on par with checks. At Dharwad there was heavy infestation of midge (21.6 – 39.6%). The entries SPV 1786, SPH 1567, SPV 1774, SPV 1616, CSH 23, SPV 462, CSV 15, SPV 1746, SPV 1742, CSH 16, CSH 18 were statistically on par with the resistant checks. On all India bases, CSH 23, SPV 1746, SPH 1567, SPV 1742, SPV 1616 were the best entries recording least damage of midge (Table 2.4).

Days to 50% flowering: The data on days to 50% flowering was recorded at Parbhani, Dharwad and Surat. At Parbhani the entries CSH 23 and CSV 17 were earliest to flower and same trend was observed at Dharwad. At Surat, the entries CSV 17, SPV 1616, CSH 16, CSH 23, SPV 1600 and SPV 1742 were earliest to flower. The earliness of flowering aids in escaping the midge damage (Table 2.5).

Head bug: The data on head bug population was recorded at milky stage. The data collected from Palem, Coimbatore, Parbhani and Indore. All centres recorded exceptionally high CVs and hence could not be included. In Zone –I the head bug population /panicle ranged from 6.4 – 24.3 with mean of 15.4. The entries CSV 17, SPV 1746, CSH 16, SPV 1616 and SPV 1742 recorded low head bug population. In Zone –II, the entries recorded 4.9–17.1 head bugs/ panicle. Local check (JJ

1041), SPV 1600, SPV 1774, SPV 462 and SPV 1616 had least head bug population. Across the zones, the entries, SPV 1600, SPV 1774, SPV 462, SPV 1616 and local checks performed better over other entries (Table 2.6).

The data collected on panicle damage rating due to head borer from Palem and Coimbatore could not be considered due to high CV. At Coimbatore the damage ranged from 1.3 – 4.9 and average rating was 3.44 and at Palem the damage rating was ranged from 1.1 to 5.7 with a mean of 3.04. SPV 1742, SPV 1746, local check (CO-28), CSV 17, CSV 15 recorded overall low damage rating (Table 2.6).

Shoot bug: Shoot bug data was recorded at Parbhani. The data on shoot bug density rating on 1-9 scale, plant damage rating (1-9), could not utilized due to high CV. The plant damage ranged from 6.65–15.46%, the mean damage was 9.3%. The entries SPH 1567, SPV 1616, SPV 1774, SPV 1786 and SPV 1600 recorded less shoot bug damage (Table 2.7).

Grain yield /plant (g) : At Parbhani, the yield ranged from 4.9–63.3 g/plant, the mean yield / plant was 42.9g. The entries CSH 16, SPV 1746, SPH 1567, SPV 1616, CSH 18, SPV 462 and local check (PVK 809) recorded significantly higher yields and they were on par to each other. Their yields ranged from 48.8–53.3g/ plant. At Surat, the yield ranged from 26.7 – 64.0 g/plant, the mean yield / plant was 49.8 g. The entries CSH 23, CSH 16, SPH 1567, SPV 1616, local check, CSH 18 and SPV 1786 recorded significantly higher yields and they were on par to each other. Their yields ranged from 55.3–64.0 g/ plant. In Zone I across locations the entries, CSH 16, SPH 1567, SPV 1616, CSH 18, CSH 23, local check, SPV 1746, SPV 462, SPV 1786, were on par with each other and top performers. The yield range was 48.8–62.5g/ plant.

At Udaipur (Zone-III), the yield ranged from 30 to 101.7 g, the mean yield was 70.7 g / plant was 70.7 g. The entries: CSV 15, SPH 1567, SPV 462, SPV 1742 and SPV 1786. The entries: SPV 1774, CSV 17, CSH 23, SPV 1746 and SPV 1616 recorded significantly higher yields and they were on par top each other. Their yields ranged from 22.7 to 72.7 g/ plant. Across the zones, the entries SPH 1567, CSH 16, CSV 15, CSH 18, SPV 462, SPV 1616, SPV 1786, CSH 23, SPV 1746, SPV 1742, CSV 17 and local check were on par to each other and significantly superior over rest of the entries (Table 2.7).

Trial 3. Advance Varietal and Hybrid Trial-III (AVHT-III, Zone III): Under AVHT for Zone III, 12 experimental lines, varieties (9) and hybrids (3), six commercial checks (CSV 15, CSH-16, SPH 1342, CSV 17, SPV 462, and SPV 1616), one local, two resistant (IS 2312, IS 2205) and one susceptible check (DJ 6514) were evaluated at eight locations (Palem, Coimbatore in Zone I; Dharwad, Akola, Indore, Surat in Zone II; and Kanpur, Udaipur in Zone III) for resistance to major pests.

Shoot fly: The data on deadhearts due to shoot fly was recorded at abovementioned centres. The data from Indore and Kanpur could not be considered due to high CV (> %). In Zone-I, at Palem, the shoot fly deadhearts ranged from 19.6–56.5% (mean deadhearts: 42.4%). The entries SPV 1733, SPV 1730 and SPV 462 recorded deadhearts on par to resistant checks (30.3–34.8%). The shoot fly deadhearts at Coimbatore ranged from 0 -56.6% with mean of 23.3%. The entries SPV 1733, CSV 17 and SPV 1774 were statistically different than checks and other entries and damage recorded > 16%.

In Zone-II at Akola, the mean damage by shoot fly was 41% and damage range was 10.3 – 59.3% DH. None of the test entries were on par to resistant checks. The entries, CSV 17, SPV 1600, SPV 1774, SPV 1730, SPV 1775 and CSV 15 were tolerant and damage in these entries ranged from 32.3 – 39.3% DH at 28 DAE. The mean damage at Dharwad was 63.5% indicating heavy infestation. None of the entries were on par to resistant checks. The entries local check, SPV 1786, SPV 1600, SPV 1775 were moderately tolerant, they recorded damage in range of 48.4- 54.8% DH at 28 DAE. At Surat the damage ranged from 22.3-75.8% DH and mean damage was 39.3% DH. The entries, SPV 1616, SPV 1600, Local check, SPV 462, CSV 15, CSV 17, SPV 1730, SPV 1774 were statistically on par to resistant check with shoot fly dead hearts ranging from 27.5 – 36% DH.

Across the locations of zone- II, the entries SPV 1600 was statistically on par to resistant check with 29.3% DH. At Udaipur (zone-III), the mean damage was 23.4% and it ranged from 7.3-92%. The entries CSH 16, SPV 1733, CSV 15 and SPV 462 were on par to resistant check, the damage ranged from 14.8 – 18% DH at 28 DAE. Across the zones, the entries, SPV 1600, local check, SPV 462, SPV 1786, SPV 462, SPV 1616 were promising recording less shoot fly damage (Table 3.1).

The data on shoot fly eggs/10 plants was recorded at Palem, Dharwad, Surat, the data from Surat could not be considered due to high CV (> 30%). At Palem, oviposition no eggs /10 plants ranged from 7.7-13 and mean was 10.5 eggs/10 plants. There was no significant differences among the entries for eggs/10 plants when compared with resistant check IS 2312, however, the entries SPV 1730, SPV 1774, local check, SPV 462, SPH 1587, SPV 1786, SPV 1746 recorded low

oviposition (7.7 – 9.7 eggs/10 plants even below check IS 2312 (12.3 eggs/10 plants). At Dharwad, the eggs/10 plants laid by shoot fly ranged from 2.3 – 20.3. The entries local check, CSV 15, SPV 1786 and SPV 1746 were statistically on par with resistant checks, the oviposition ranged from 2.3 – 5.3 eggs/10 plants indicating least preference for oviposition.

Across the locations, the oviposition ranged from 4.2 – 12.1 eggs/10 plants, mean being 7.2 eggs/10 plants. Among the entries, most of them were on par to resistant checks, however, local check, CSV 15, SPV 1786, SPV 1730, SPV 462 were least preferred for oviposition (Table 3.2). Other morpho-physiological traits such as seedling vigor, leaf glossiness and seedling height have not been recorded in any of the centers during Kharif 2007.

Stem borer: At Coimbatore stem borer tunneling ranged from 9.7 – 92.2%, the mean damage was 47.8%. Among the entries SPV 462, SPH 1587, SPV 1733, CSV 15, SPV 1774, local check (CO-28) were on par with the resistant checks recording least damage. At Coimbatore the entries SPV 462, Local check (CO-28) recorded damage on par with the resistant check (Table 3.2).

The data on stem borer deadheart % at 45 DAE from Palem, Indore, Udaipur and Kanpur were not considered due to exceptionally high CV (> 30%). At Coimbatore, the damage ranged from 0- 25% mean damage was 10.6%. Among the entries, SPV 1600, SPV 1775, local check (CO-28) were tolerant and on par with resistant check (IS 2205). At Surat (Zone-II), the stem borer deadhearts ranged from 19.1 – 36.7% and mean damage was 27.4%. Among the entries, SPH 1342, CSH 18, SPV 1600, SPV 1774, local check, CSV 17, CSH 16 recorded less damage (22.9 – 25.9% DH) and were on par with resistant check IS 2205. Across the locations and zones, the damage ranged from 6.9 – 24.6 % deadhearts, the entries local check, CSH 16, CSV 17, SPV 1730, SPH 1587 AND SPV 1600 were promising (Table 3.3).

The data on leaf injury to the plants due to stem borer recorded at Palem, Indore could not be considered due to high CV (> 30%). At Coimbatore, the damage ranged from 0 to 34.3% and mean damage was 14.6%. Among the entries SPV 1600, SPV 1775, local check was on par with resistant checks (Table 3.4). At Akola, the leaf injury by stem borer ranged from 17.7 – 49% and mean damage was 32.1%. The entries, SPV 1746, CSH 16, SPV 1786, CSV 17, CSH 16, SPV 1742, SPH 1596, CSV 15, SPV 1600 and SPV 1730 were tolerant and on par to resistant check IS 2205. The damage range at Surat was 24.1- 31.6% and mean was 40.2%. The entries, SPV 1616, SPV 1774, SPV 1733, CSH 16, SPH 1342, CSH 18, CSV 17, CSV 15, SPV 1600, local check were on par to IS 2205. In zone II, CSV 17, CSH 16, SPV 1786, SPV 1746, SPV 1600 were promising. At Udaipur (zone-III), the stem borer leaf injury plants ranged from 5.2 – 9.2%. Most of the entries were on par to resistant check IS 2205, however, SPH 1596, SPH 1587, SPV 1742, SPH 1342 recorded least injury. Across the zones the damage ranged from 13.6 – 24.1%, mean damage was 18.5%. Most of the entries performed on par to resistant check (IS 2205), however the entries CSH 16, SPV 1600, SPV 1746, SPV 1786, CSV 15 were promising (Table 3.4).

The data on peduncle damage plants affected by stem borer was recorded at Akola, Dharwad could not be considered owing to exceptionally high CV (> 30%). At Palem, the peduncle damage in entries ranged from 11.5 – 35.4% and mean was 20.4%. Among the entries SPV 1600, SPV 1774, SPV 1786, SPV 1775, SPV 1742, CSH 18, SPV 1733, SPV 1616, SPV 1730, CSV 15 were on par to IS 2205 (resistant check). The peduncle damage in these entries ranged from 11.5 – 20.1%. The peduncle damage at Coimbatore ranged from 18.3 – 77.3%. The entries SPV 1733, SPV 1774, SPV 1742, SPV 1775, SPV 1730, SPV 1786 and CSH 16 recorded least damage. Across the zones, the entries SPV 1775, SPV 1774, CSH 16, SPV 1742, SPV 1730 suffered least peduncle damage (Table 3.5).

Midge: Spikelet damage due to midge was recorded at Coimbatore and Dharwad. At Coimbatore, the entries CSV 17, SPH 1342, SPV 462, CSH 16 and SPH 1587 recorded least damage (0-2.2%) and were on par to resistant check. At Dharwad heavy midge infestation was observed (21-34%). Across the locations, the entries, CSV 17, SPV 1342, SPH 1587 and SPV 1742 were the best recording least midge damage (Table 3.2).

Midge panicle damage rating (1-9) at Coimbatore indicated low infestation. The damage range was 1.05–3.16 and mean was 1.33. Most of the entries recorded damage on par to resistant checks, however the entries CSH 18, SPV 1746, SPH 1596, SPH 1587, local check (CO-28), CSV 17, SPV 462, SPH 1342, CSH 16, SPV 1730, SPV 1733, SPV 1786, SPV 1742 and SPV 1774 recorded lowest damage rating about 1.05 (Table 3.3).

Head bug: Head bug population density at flowering was recorded at Palem, Coimbatore and Indore. The data from Palem and Indore could not be considered due to high CV (> 30%). At Coimbatore head bug population on panicles ranged from 2–16.3 bugs/ panicle. The entries CSH 16, SPH 1342 suffered least damage. In terms of score same trend was observed, the damage rating ranged from 1.15–4.61. The entries CSH 16, SPH 1342 recorded least damage score (Table 3.6)

Days to 50% flowering: At Dharwad, CSV 17, SPH 1342, SPH 1596, SPH 1587, CSH 18, CSH 16, SPV 1774, SPV 1616 were earliest to flowering (67-74 days) and were par to each other. Overall CSV 17 was to flowered between 64-67 days (Table 3.4).

Grain yield & its components: The grain yield data was recorded at Surat and Udaipur. At Surat, the lines, CSH 18, SPH 1596, SPH 1587, SPH 1342 and CSH 16 recorded superior yield. SPH 1587, SPV 1746, SPH 1596, CSH 16 recorded higher yield in comparison to other entries. Across zones, SPH 1587, SPV 1746, SPH 1596, CSH 16, SPV 1600 were promising entries (Table 3.5).

Trial 4. Initial Varietal Trial (IVT) (Location: Nine Centres): In IVT (Grain Sorghum), 16 experimental varieties, 3 commercial checks (CSV 15, CSV 17, SPV 462), 3 resistant (IS 2312, IS 18551, IS 2205), one susceptible check (DJ 6514) and respective local check were evaluated for resistance to key pests at 9 locations namely Palem, Coimbatore (Zone I), Parbhani, Akola, Dharwad, Indore, Surat (Zone II), Kanpur and Udaipur (Zone III).

Shoot fly: The predominant component of resistance to shoot fly is antixenosis for oviposition. Oviposition (shoot fly eggs/10 plants) was recorded only at Palem, Parbhani, Dharwad and Surat. Seedlings infested with eggs were recorded only at Palem center. The entries SPV 1814, CSV 17 and resistant checks showed less infested seedlings with eggs. In zone-II, relatively lower oviposition (eggs/10 seedlings) was observed in SPV 1808, CSV15 than other entries but later than resistant check (4.2). The shoot fly deadhearts at 28 Days after emergence (DAE) recorded from Zone-I (Palem, Coimbatore) and was ranged from 0.0 to 54.4 % in test materials, but not considered due to low deadhearts % in DJ 6514 (<70%).

In Zone-II, the damage range was relatively moderate 15.4 to 84.8 % with trial average was 38.0 %. However, Akola center has low DH in DJ 6514, therefore not considered. There was not a single test entry performed better than resistant check at 28 DAE for shoot fly resistant. However, the entries: SPV 1809, SPV 1812, and SPV 1817 at Zonal II performed well. In Zone-III relatively lower damage due to shoot fly was recorded. It was ranged from 10.1 to 88.4 with average of 22.3 %. However two test varieties namely SPV 1821, SPV 1807 and CSV 17 relatively showed better performance than other test material in Udaipur. But none were above than resistant check in Zone -III too. In Zone -III, SPV 1821, SPV 1807, and CSV 17 has relatively performed better than other test entries. At national level, none of experimental varieties performed significantly superior than resistant checks at 1 and 5% level (Table 4.1).

Spotted stem borer: The percent data on leaf injured plants due to stem borer were recorded at Palem, Coimbatore (Zone I), Parbhani, Akola, Indore, Surat (Zone II) and Udaipur (Zone III). It was relatively lower leaf damage plants % (7.1 to 17.7%) in Zone -I, whereas in Zone -II, it was ranged from 19.5 to 31.1%. All the test entries found at par with resistant check. Surprisingly, the relatively lower stem borer leaf injured plants was recorded in DJ 6514 (susceptible check) from Zone I and II. In Zone -III, only eight test entries are at par with resistant checks. On national level, all test entries are not different from the check. Again DJ 6514 has averaged lowest leaf damage among the test entries (Table 4.4). The data on deadhearts caused by stem borer was recorded at 45 DAE. The test entries, SPV 1808, CSV 15, SPV 462 and SPV 1821 recorded lower damage than resistant check (IS 2312) at national level and were not significantly different than that of resistant check. Interestingly, the data from all centers (Palem, Parbhani, Indore, Udaipur and Kanpur except Coimbatore and Surat) have recorded high CV (> 30%). Hence the data from these centers could not be considered for comparisons (Table 4.3). The data on stem and peduncle tunneling percentage was recorded only from Coimbatore (Table 4.3).

The stem tunneling % due to stem borer in SPV 1816, CSV15, SPV 1827 and SPV 1819 showed lower damage and significantly superior to other entries and susceptible check DJ 6514. Whereas, SPV 1812, SPV 462, and CSV 15, SPV 1819 and SPV 1821 showed significantly lower peduncle damage % than resistant check (Table 4.2). The peduncle damage % due to stem borer was recorded at Palem, Coimbatore, Parbhani, Akola and Dharwad. In Zone I, the entries SPV 1812, CSV 15, SPV 1819, SPV 1821 have recorded lower peduncle damage than resistant check IS 2312. In Zone II, SPV 1807 and local check have found lower than resistant check (Table 4.5).

Midge: The spikelet damage by midge was recorded at Coimbatore and Dharwad. The entries SPV 1813, SPV 1814, SPV 1819, IS 2205 and SPV 1827 recorded low spikelet damage but DJ 6514 was recorded 12.5 % damage. The lowest damage was recorded in SPV 1814 and highest damage was recorded in CSV 17. It is interestingly and consequently found that shoot fly resistant check IS 2312 is highly susceptible to midge and vice versa (Table 4.4). Panicle damage rating (1-9) was only recorded at Coimbatore. There are no significant differences in panicle damage rating among the test entries (Table 4.3).

Days to flowering (50%): The days to 50% flowering were recorded at Parbhani, Dharwad and Surat. There were significant differences found amongst the test entries at national level. Earliest was recorded in CSV 17 (64 days) and longest in IS 18551 at 79 days (Table 4.5).

Head bug: The colonization of head bug population was recorded at milky stage in Palem, Coimbatore in Zone -I and Parbhani, Indore in Zone-II. Significantly lower population colonization of head bugs was recorded on the entries of SPV 1810, local check, IS 2205, and IS 2312. While, SPV 1810, SPV 1818, SPV 1821, IS 2312 and IS 2205 in Zone II. Overall, SPV 1809, SPV 1810, SPV 1821, IS 2312 and IS 2205 recorded relatively lower population (Table 4.6). Panicle damage due to head bug was recorded in the scale of 1-9 at ear head stage at Coimbatore and Palem centres only. Relatively high damage rating was recorded at Palem (Trial mean 4.0). The low damage rating due to head bug was observed in SPV1815, SPV 462, SPV 1821, IS 2312 and IS 2205. Highest damage rating was observed in SPV 1808 (5.7) in Palem and lowest (1.2) was recorded in IS 2205 in Coimbatore (Table 4.6).

Shoot bug: The shoot bug infestation % was recorded only at Parbhani centre only. The damage % in test entries have shown significantly lower damage and comparable with local check PVK 809. The entries DJ 6514, local check PVK 809, CSV 17, SPV 1813 and SPV 1811 were recorded > 8% plant damage due to shoot bug (Table 4.7).

Grain yield: Grain yield/plant (g) was recorded at two centers (Parbhani, Surat and Udaipur). Udaipur centre has recorded highest average yield 90.7 g/plant. The data on grain yield has recorded high CV at Udaipur. However, the entries SPV 1827, SPV 1807, SPV 1808, SPV 1816, and SPV 1827 have recorded highest yield than local check. SPV 1827 recorded highest grain yield (163.8 g/plant) (Table 4.7).

Trial 5. Initial Hybrid Trial (IHT) (Location: Nine Centres): In IHT, sixteen experimental hybrids, three commercial hybrids, one local check along with three resistant (IS 2312, IS 2205, IS 18551) and one susceptible (DJ 6514) checks were subjected to evaluate for resistance against key pests of sorghum at 9 locations (Palem and Coimbatore in Zone I; Parbhani, Akola, Dharwad, Indore and Surat in Zone II; and Kanpur and Udaipur in Zone III).

Shoot fly: Deadhearts caused by the shoot fly was recorded at 28 DAE, at Palem and Coimbatore (Zone I), Parbhani, Akola, Dharwad, Indore, Surat (zone -II) and Udaipur and Kanpur (Zone -III). Locations Palem, Coimbatore, Akola and Kanpur were rejected due to low infestation in susceptible check DJ 6514. There is not a single entry that showed lowest deadhearts due to shoot fly than resistant check neither in Zone- II nor in Zone-III. Significantly low deadhearts were recorded by the resistant check alone mostly in all locations. At national level, only local check was relatively performed better than test material but not at par with resistant check (Table 5.1). Antixenosis for oviposition was recorded at seedling growth stage at Palem only. The CV was very high, therefore not considered for interpretation (Table 5.2). The oviposition of shoot fly was recorded at Palem, Parbhani Dharwad and Surat. Among the entries SPH 1602, SPH 1603, SPH 1613, and local check showed significantly low oviposition at 14 DAE at national level (Table 5.2).

Spotted stem borer: The data on stem and peduncle tunneling percentage was recorded only from Coimbatore (Table 5.2). The stem tunneling % due to stem borer was recorded lowest in IS 2205. Other entries SPH 1602 and SPH 1607 have recorded relatively lower tunneling damage but not par with IS 2205 (Table 5.2). The peduncle tunneling % due to stem borer was recorded only at Coimbatore. The entries SPH 1617, SPH 1608, SPH 1609 and local check CO 28 recorded lower tunneling than resistant check IS 2312 (Table 5.2).

The incidence of deadhearts caused by the spotted stem borer at 45 DAE was recorded in nine locations (Palem and Coimbatore in Zone -I, Parbhani, Indore and Surat in Zone II and Kanpur and Udaipur in Zone III). The entries SPH 1584, SPH 1597 and SPH 1342 recorded lowest deadhearts in Parbhani in zone II. The entries SPH 1608, SPH 1610 and SPH 1616 recorded lower deadhearts in zone I. The entries SPH 1606 and CSH 16 recorded relatively lower damage in Zone-II and the entries SPH 1603, SPH 1608 and SPH 1612 recorded lower stem borer damage but not lower than resistant check. At national level, all test hybrids showed relatively lower deadhearts due to stem borer except DJ 6514. However, the entries CSH 16, SPH 1617, SPH 1615, and SPH 1616 recorded relatively lower damage but not lower than check (Table 5.3).

The spotted stem borer damage in terms of leaf feeding on damaged plants (%) was recorded at Palem, Coimbatore, Akola, Parbhani, Indore, Surat and Udaipur. In view of high CV, the data from all centres except Coimbatore and Surat was not considered. The lowest leaf feeding damage was observed in Indore (0 -10.9%) and highest range was noticed in Surat (22.2 -56.4%). Among the test entries, SPH 1608, SPH 1613, SPH 1615, SPH 1616, and SPH 1617 1594 were recorded

significantly lower leaf feeding, in Zone-I. The leaf feeding between the tests hybrids did not differ significantly in Zone-II. While in Zone –III, SPH 1605, CSH 16, CSH 18, SPH 1613, SPH 1614, SPH 1606, SPH 1607, SPH 1608 and CSH 23 showed relatively lower plant damage percentage in Zone III. At National level, SPH 1617, CSH 18, SPH 1602, SPH 1608, SPH 1609 and SPH 1615 performed very well and at par with resistant check (Table 5.4). The peduncle damage plants % due to stem borer was recorded at Palem, Coimbatore, Parbhani, Akola and Dharwad. In Zone I, the entries CSH 18, local check and SPH 1609 have recorded lower peduncle damage but not lower than resistant check IS 2312. In Zone II, SPH 1604, SPH 1617, CSH 18 and local check have found relatively lower peduncle damage. At national level, SPH 1604, SPH 1606, CSH 18, local check, SPH 1615 and SPH 1617 performed better and comparable with check (Table 5.5).

Midge: The spikelet damage by midge was recorded at Coimbatore and Dharwad. The CV is high in Coimbatore and hence not considered. At national level all entries except SPH 1602 recorded lowest spikelet damage due to midge and found at par with resistant check DJ 6514. Highest spikelet damage (43.1%) was noticed in SPH 1602 (Table 5.4). The first five entries that showed lower spikelet damage after DJ 6514 are IS 18551, local check, SPH 1612, SPH 1507 and CSH 16.(Table 5.4). Panicle damage rating (1-9) was only recorded at Coimbatore. SPH 1602 recorded highest rating (8.7), while CSH 16 recorded lowest rating (0.8) followed by DJ 6514 (Table 5.3).

Head bug: The colonization of head bug population was recorded at milky stage in Palem, Coimbatore in Zone –I and Parbhani, Indore in Zone-II. Significantly lower population colonization of head bugs was recorded on the entries of SPH 1602, IS 18551, IS 2205, SPH 1607 and IS 18551 in Zone-I. While in Zone –II, SPH 1603, SPH 1604, SPH 1615, local check and CSH 18 were recorded lower (<10 bugs/panicle) head bug population (Table 5.6). Panicle damage due to head bug was recorded in the scale of 1-9 at ear head stage at Coimbatore and Palem centres only. Relatively high damage rating was recorded at Palem (Trial mean 4.3). The low damage rating due to head bug was observed in SPH 1602, SPH 1616, IS 2205, IS 18551 and IS 2312. Highest damage rating was observed in SPH 1609, CSH 23 in Palem and lowest was recorded in IS 2205 in Coimbatore (Table 5.6).

Shoot bug: Now a days, shoot bug is not confined to post rainy sorghum, but becoming a serious pest causing plant stand loss during Kharif season in sorghum growing areas of Maharashtra. The data recorded at Parbhani showed low plant damage by shoot bug and the CV is high. However, the entries SPH 1603, SPH 1604, SPH 1602 and SPH 1610 were recorded relatively lower damage than resistant check. The highest damage was recorded in IS 2312 as 14.7% and followed by SPV 1612 and SPH 1613 (Table 5.7).

Days to flowering (50%): The days to 50% flowering were recorded at Parbhani, Dharwad and Surat. There were significant differences found amongst the test entries at national level. Earliest was recorded in SPH 1602 (63days) and longest duration of flowering was observed in DJ 6514 i.e. 84 days, the same entry was recorded longest days to flower at 103 days in Dharwad (Table 5.5).

Grain yield : Parbhani, Surat and Udaipur centre has recorded grain yield. Significant differences were observed between the test entries for grain yield plant⁻¹. The grain yield expression was high at Udaipur centers, and moderate at Parbhani and Surat centers. The entries SPH 1615, SPH 1616, SPH 1605, SPH 1610 and SPH 1611 recorded higher yields under biotic stresses (< 80 g) at national level. The influences of abiotic stresses on plant height, waxy bloom, and 100 seed weight were not recorded by any centers (5.7).

II. Evaluation of dual-purpose sorghum experimental varieties/ hybrids/ parental lines for resistance to insect pests

Trial-6 Advanced Varietal and Hybrid Trial (Dual purpose sorghum): In AVHT (dual purpose sorghum) trial, one experimental hybrid, eight varieties, one commercial hybrid, one commercial variety, one local check along with three resistant (IS 2312, IS 18551, IS 2205) and susceptible (DJ 6514) checks were evaluated for resistance against key pests of sorghum. The trial was conducted at five locations, Coimbatore (Zone I), Dharwad, Surat (Zone-II), Kanpur and Udaipur (Zone-III).

Shoot fly: Antixenosis for oviposition by the shoot fly (No of shoot fly /10 plants) was recorded at Dharwad and Surat centre at 14 DAE.. All entries showed relatively lower oviposition and are at par with resistant check except SPH 1467, CSH 18 and DJ 6514. The most significant entries were CSV 15, SPV 1616, SPV 1754, SPV 1750, SPV 1753 and SPV 1781 recorded lower number of eggs on seedlings after resistant checks. The SPH 1467 and susceptible check (DJ 6514) recorded highest number of eggs/ 10 seedlings (Table 6.1). The dead hearts caused by shoot fly was recorded at 28 DAE

recorded at five locations, Coimbatore (Zone I), Dharwad, Surat (Zone-II), Kanpur and Udaipur (Zone-III). The data on shoot fly dead hearts at 14, 21 DAE was not considered since very few centers have recorded the data and was not comparable. Some of the locations: Coimbatore and Kanpur have recorded low infestations (< 70%) in susceptible check DJ 6514 and hence they were not considered for comparisons. Moreover the data from Surat and Kanpur centre were not considered due to high CV (>25%). In view of national average, the entries SPV 1754, SPV 1779, and local check have recorded lower shoot fly dead hearts and can be compared with resistant check IS 2312. The resistant check (IS 2205) recorded lowest 17.2 %, whereas susceptible check DJ 6514 has recorded 80.6 % dead hearts caused due to shoot fly (Table 6.1).

Spotted stem borer: The data recorded on stem tunneling and peduncle tunneling (%) by Coimbatore centre only and hence was not considered (Table 6.2). Leaf injury on plants due to stem borer (LD %) were recorded at Coimbatore, Surat and Udaipur. All entries except SPV 1782 and CSH 18 recorded lower leaf damage(%) and found at par with resistant check (IS 2205). Highest leaf damage (%) was recorded in CSH 18 (Table 6.3). The data on peduncle damage recorded at Coimbatore and Dharwad. Surprisingly, susceptible check (DJ 6514) recorded lowest peduncle damage at both centre, and hence not considered. However (DH %) at 45 DAE were recorded at four locations, Coimbatore, Surat, Udaipur and Kanpur.

Overall, SPV 1714, SPV 1616, SPV 1779 recorded (< 10 %) deadheart. However the other entries except SPV 1782, CSH 18 recorded equally found good as of resistant check IS 2205. Susceptible check recorded highest deadhearts (14.9%) (Table: 6.3). At Coimbatore DJ 6514 has recorded 0 % deadhearts, hence not considered. However the promising entries at other centres were: SPV 1750, SPV 1616 (Surat), CSH 18, SPV 1750, SPV 1616 (Udaipur) and at Kanpur entries SPV 1779, SPV 1754, SPV 1616 recorded comparatively low deadhearts. Coimbatore and Surat recorded lower CV (<25%) (Table 6.3).

Midge: The spikelet damage (%) due midge was recorded at two centres (Coimbatore and Dharwad) and midge damage rating (scale 1-9) was recorded at Coimbatore only. At Dharwad centre the spikelet damage was considerably uniform and had good pressure of midges. The damage was ranged from 19.0 to 34.3 (mean 26.7%), whereas at Coimbatore it was ranged from 0.01 to 16.3%) with a mean of 7.5% (Table 6.2). Overall, DJ 6514 (resistant check), IS 2205, CSH 18, SPV 1778 and local check at respective centres were performed well (Table 6.3). The damage rating (1-9) was very low (3.2) and hence was not considered.

Head bug: The colonization of head bug population and panicle damage rating (1-9) was recorded at milk stage in Coimbatore only. Significantly lower population colonization (5.1 to 21.4 head bugs/panicle) was recorded. The entries of SPV 1753, IS 2312, IS 2205 and CSV 15 relatively found better than other entries. The damage rating was recorded highest (5.8) in SPV 1779 and DJ 6514 (Table 6.4).

Days to 50 % flowering: The data on days to flowering was recorded at Dharwad and Surat. Days to flowering 69 (SPV 1753) to 87 (IS 2205) in Dharwad and 71 (Local check) to 84 (IS 2205) at Surat were recorded (Table 6.4)

Grain yield (g)/ plant : The grain yield data was recorded at Surat and Udaipur centre only. At Surat, entries SPV 1778, SPH 1467, SPV 1754, CSV 15, SPV 1781 and local check recorded significantly higher yields (> 45g/plant). At Udaipur, entries SPV 1467, CSV 15, CSH 18, SPV 1778, SPV 1754, SPV 1750 recorded higher grain yield (>60 g/plant) and were on par with each other (Table 6.4). The yields were higher at Udaipur than Surat. Overall the entries, SPH 1467, SPV 1778, CSV 15 and CSH 18 recorded more grain yield (>65g/plant) as compared to other entries (Table 6.4).

Trial-7. Initial Varietal Trial (Dual purpose sorghum): In IVT (dual purpose sorghum) trial, seven varieties, one commercial variety, one local check along with three resistant (IS 2312, IS 18551, IS 2205) and susceptible (DJ 6514) checks were evaluated for resistance against key pests of sorghum. The trial was conducted at five locations, Coimbatore (Zone I), Dharwad, Surat (Zone-II), Kanpur and Udaipur (Zone-III).

Shoot fly: The trial was conducted in Zone I and II at one location only at Coimbatore and Dharwad respectively. In Zone – III, it was conducted at three locations (Surat, Udaipur and Kanpur). Antixenosis for oviposition on seedlings was recorded at two centers (Dharwad and Surat). Overall IS 2205 has recorded lowest oviposition (1.8 eggs on 10 plants). Whereas, susceptible check (DJ 6514) recorded 12 eggs on ten plants. The data on Antixenosis was recorded and showed statistically significant. The entries SPV 1825, IS 2312, SPV 1826, IS 18551 and local check recorded relatively least oviposition (Table 7.1).

The data recorded on shoot fly dead hearts at 28 DAE at Coimbatore, Dharwad, Surat, Kanpur and Udaipur. The locations Coimbatore and Kanpur rejected due to low infestation in susceptible check DJ 6514 (<70%). In Zone II, the test entries SPV 1825, CSV 15 and local check at respective locations have shown relatively lower dead hearts caused by shoot fly at 28 DAE. IS 18551 has recorded 16.9 % dead hearts, whereas DJ 6514 has recorded 81.3 % dead hearts. In Zone III, the test entries SPV 1822, SPV 1616 and local check at respective locations have shown relatively lower dead hearts caused by shoot fly at 28 DAE. IS 2205 has recorded lowest deadhearts (8.5 %), while, DJ 6514 has recorded highest deadhearts (89.0 %) due to shoot fly (Table 7.1). Overall, local checks, CSV 15, SPV 1616, SPV 1825 and SPV 1822 recorded relatively lower infestation (<40%) due to shoot fly and found on par with IS 18551, which has affected least damage at national level (Table 7.1).

Spotted stem borer: The data recorded on stem tunneling and peduncle tunneling (%) by Coimbatore centre only and hence was not considered for comparison (Table 7.2). Leaf injury on plants due to stem borer (LD %) were recorded at Coimbatore, Surat and Udaipur. Overall all entries except SPV 1823, SPV 1616, SPV 1822 and local check recorded lower leaf damage (%) and found at par with resistant check (IS 2312). Highest leaf damage (24 %) was recorded in SPV 1825 (Table 7.3). The data on peduncle damage was recorded at Coimbatore and Dharwad. Interestingly, susceptible check (DJ 6514) recorded lowest peduncle damage and IS 2205 (one of resistant check) recorded highest peduncle damage (41.6%). Whereas, deadheart (DH %) at 45 DAE were recorded at four locations, Coimbatore, Surat, Udaipur and Kanpur. Overall, SPV 1823, SPV 1616 and local check recorded < 10 % deadheart. However the other entries except SPV 1825 and DJ 6514 were equally good as of resistant check IS 2205. Susceptible check recorded highest deadhearts (17.1 %) At Coimbatore DJ 6514 has recorded lower % of deadhearts (2.4%), hence not considered. However the promising entries at other centres were: SPV 1824, SPV 1616 (at Surat), SPV 1823, SPV 1616, local check (at Udaipur) and entries SPV 1823, SPV 1821, SPV 1825, and SPV 1616 (at Kanpur) recorded comparatively low deadhearts (Table 7.3).

Midge: The spikelet damage (%) due midge was recorded at two centres (Coimbatore and Dharwad) and midge damage rating (scale 1-9) was recorded at Coimbatore only. At Dharwad centre the spikelet damage was considerably uniform and had good pressure of midge population. The damage was ranged from 15.3 to 43.7 (mean 29.0 %) at Dharwad, whereas at Coimbatore it was ranged from 0.0 to 28.9 % with a mean of 7.5 % (Table 7.2). Overall, DJ 6514 (midge resistant check), IS 2205, IS 2312, SPV 1824, SPV 1616 and SPV 1822 were performed well (Table 7.3).

Head bug: The colonization of head bug population/panicle and panicle damage rating (1-9) was recorded at milk stage in Coimbatore only. Significantly lower population colonization (2.1 to 22.3 head bugs/panicle) was recorded. The entries of SPV 1826 and SPV 1821 relatively found better than other entries. The damage rating was recorded highest (5.0) in DJ 6514 and lowest in IS 2205 (Table 7.4).

Days to 50 % flowering: The data on days to flowering was recorded at Dharwad and Surat. Days to flowering 70 (SPV 1821) to 89 (IS 1825) in Dharwad, whereas, 73 ((Local check) to 80 (DJ 6514) at Surat were recorded (Table 7.4)

Grain yield (g)/ plant: The grain yield data was recorded at Surat and Udaipur centre only. At Surat, entries SPV 1822, SPV 1616, SPV 1824, SPV 1821, and local check recorded significantly higher yields (> 35g/plant). At Udaipur, entries SPV 1823, SPV 1616, CSV 15, SPV 1824 and SPV 1822 recorded higher grain yield (>56 g/plant) and were on par with each other (Table 6.4). The yields were higher at Udaipur (mean: 67 g/plant) than that of Surat (mean: 32.7 g/plant). Overall the entries, SPV 1822, SPV 1823, SPV 1616, SPV 1824 and local check recorded more grain yield (>57 g/plant) as compared to other entries (Table 7.4).

III. Screening of pest resistant nurseries against key pests

Trial 8: Shoot fly Resistant Nursery (SFN) - Kharif 2007: The trial was conducted at three locations, Hyderabad (Zone-I), Akola (Zone – II) and Udaipur (Zone- III). Fourteen test entries, 2 resistant checks, one susceptible check and one local check were evaluated for resistance to shoot fly.

Oviposition on seedlings was recorded only by Hyderabad centre. However, the data on shoot fly eggs/10 plants at Hyderabad was rejected owing to high CV (35.2 %). The deadhearts caused by the shoot fly was recorded at 28 DAE. At Hyderabad (Zone-I) the shoot fly incidence among the entries ranged from 22.2 to 88.9%. The test entries NRCSFR07-06, SUENT 13 and NRCSFR07-4 recorded lower deadhearts and were on par with resistant checks (IS 18551, IS 2312) at 5% level. The data from Akola was not considered for comparison due to low deadhearts formation (<70%) in the susceptible

check (DJ 6514) and could not be considered either for zonal or all-India averages. At Udaipur (Zone III), the shoot fly deadhearts ranged from 9.0–83.9 %. The entries NRCSF-07-3, SUENT 14, NRCSFR07-4 recorded lower deadhearts (12.2 – 15.0%) and were significantly superior compared to other entries (Table 8.1).

On all India basis the entries SUENT 13, ICSV 705, NRCSFR07-4, SUENT 12, NRCSFR07-5, SUENT 14 and SUENT 15 were superior, the deadhearts ranging from 26.5–33.7% and were statistically on par with resistant checks IS 18551 and IS 2312 (Table 8.1).

IV. Evaluation of inter-disciplinary resistant materials against key pests

Trial 9. Pest and Disease Resistant Nursery (PDRN) -Kharif 2007.: Efforts were initiated to conduct interdisciplinary trials. The first pest and disease nursery (PDRN) trial was taken up with a view to identify insect pest and disease resistant material. Planted 12 test entries (consisting of 6 grain mold resistant entries and 4 shoot fly resistant entries along with, susceptible and local check each one were tested for resistance against shoot fly, stem borer, grain molds and foliar diseases at three locations viz., at Parbhani, Dharwad (Zone II) and Udaipur (Zone III)

Disease resistance

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

Downy mildew: Resistance to downy mildew was observed in the shoot fly and stem borer line i.e. NRCSFR 06-1. It is resistant to all foliar diseases viz., rust, zonate leaf spot and target leaf spot as they have recorded high levels of resistance.

Pest resistance

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

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

Multiple resistant: NRCSFR06-1 has identified as multiple resistant source to shoot fly, stem borer, foliar diseases viz., rust, zonate leaf spot, target leaf spot and downy mildew.

V. Evaluation of Marker Assisted Selected (MAS) progenies for shoot fly resistance

Trial 10.1: Screening of BC₂F₄ MAS progenies against shoot fly resistance (material contributed by Parbhani centre). The trial was conducted at three locations viz., (Zone-I: Hyderabad, Zone-II: Dharwad and Parbhani) and the material was planted around third week of July to first week of August 2007 involving a total 32 entries (23 BC₂F₄ MAS progenies, 3 resistant checks, 1 susceptible check, 1 local check, 2 RILs and 2 susceptible recurrent parents. The entries were evaluated in two-row plots with three replications against shoot fly using fish meal technique. The observations were recorded on number of shoot fly eggs per 5 plants at Dharwad, Hyderabad, Parbhani; no. of plants with eggs (%) at Parbhani; and deadhearts (%) at Dharwad, Parbhani and Hyderabad at 14-, 21-, and 28- days after emergence (DAE).

Table 10.1 shows that there are no significant differences in eggs infested plants at 1% level, the least eggs infested plants were noticed in MAS 1076-1 (73.8%). The no. of eggs per 5 plants ranged from 1.6 to 5.9 across locations. The resistant check (ICSV 705, IS 2312 and IS 18551 recorded 45% deadhearts, while susceptible check (DJ 6514) showed 79.9 % deadhearts. The recurrent parents 20B and KR 192 were highly susceptible with more than 85% deadhearts. Among the

MAS progeny, for deadhearts at 28 DAE, progenies MAS 1061-1, MAS 1062-1, MAS 1062-3, MAS 1062-7, MAS 1076-1, MAS 1261-3 at Parbhani; MAS 1062-3, MAS 1261-3 at Hyderabad were found to be at par with resistant checks at 5% level, while at Dharwad location no entry was recorded lower deadhearts% than resistant checks. Across locations, the MAS progenies of 20B viz., MAS 1062-3, MAS 1076-1, and MAS 1261-3 recorded lower infestation and were at par with resistant check at 5%.

Trial 10.2: Screening of MAS progenies against shoot fly resistance (material contributed by Bijapur centre): The second trial was conducted with seventeen entries (10 BC₁F= test entries, 3 resistant check, 1 susceptible check, 1 local check and 2 resistant parents) only at one location, Hyderabad due to less seed. The trial was planted with one row plot with three replications. Fish meal was applied to enable uniform and sufficient pressure of shoot fly for screening. The observations were recorded on number of eggs of shoot fly per 5 plants and shoot fly deadhearts (%) at 14-, 21- and 28- days after emergence (DAE). However the data of 28 DAE is given in table 10.2.

Table 10.2 reveals that the eggs per 5 plants ranged from 1.7 to 3.9 and the MAS entries RGF123051 (29B)-63S, RSF051 (7B)-1S, RSF052(8A)-9S and R 354 recorded lower eggs, and were to be on par with resistant checks at 5% level. For the deadhearts, all entries except RGF 123051(29B)-63S, RSG123051 (29B)-112S and DJ were found to be good. The lowest deadheart was recorded on RSF05 (7C)-6S and was lower than resistant check IS 18551. In addition, the entries RSF051 (7B)-1S, RSF051 (7C)-6S, RGF 103051(29B)-101S and RGF 103054 (26A)-22S recorded <40% deadhearts. The resistant check IS 18551 recorded 30.5% deadhearts, while susceptible check DJ 6514 showed 79.2% deadhearts.

VI. Evaluation of sweet sorghum experimental varieties/ hybrids/ parental lines for resistance to insect pests

Trial 11: The Advanced Sweet Sorghum Varietal and Hybrid Trials: An advanced sweet sorghum varietal and hybrid trial (ASSVHT) was conducted during Kharif 2007 at three locations viz Warangal, Rahuri and Akola. The trial comprised of total 20 entries; 10 varieties, 4 hybrids, three sweet sorghum checks, one local check, one susceptible and one resistant check. The data from Warangal could not be considered due to exceptionally high CV (> 30%).

Shoot fly: The data on shoot fly deadhearts at 28 DAE was recorded. At Rahuri the deadheart % was ranged from 48.7-98.1. The entries local check, SPSSV 4 and CSV 19SS recorded significantly lower deadhearts (60.5-67.1 %). The mean damage was 81 % at Rahuri. At Akola, the damage ranged from 12-60 %. The entries CSV 19SS, ICSV 714, SPSSH 26, SPSSV 20 and SPSSV 27 recorded significantly low deadhearts (19-32%). The mean damage was 40.9%. At India basis, the deadhearts ranged from 11-54.2%, the mean damage being 42.6%. The entries ICSV 714, CSV19SS and SPSSV 4 recorded significantly low damage (11-35.7 % deadhearts)

Stem borer: The damage caused by stem borer was recorded at Rahuri and Warangal. The data from Warangal was rejected due to very high CV. At Rahuri, The deadhearts caused by stem borer ranged from 12.7 - 31.3%. The entries SPSSH 19, SPSSV 27, CSV 19 SS, SPSSV 30, SPSSV 15, CSH 22 SS, SPSSV 4, SPSSV 28, SPSSH 25 and SPSSV 11 recorded significantly lower deadhearts in the range of 12.7-24.9% and were on par with resistant check IS 2205 (Table 11.1). The leaf injury was on plants (%) was recorded only at Akola. Due to high CV%, it was not considered for discussions. The peduncle damage due to stem borer was recorded at Akola only. All entries found significantly differed from each others. The entries SPSSV 27, SPSSH 19, SPSSV 11 and SSV 84 (check) found relatively better than other entries and recorded peduncle damage (<30%) and comparable with resistant check (Table 11.1).

VII. Development of new sources of resistance for genetic diversity (under group efforts – breeders and entomologists)

Evaluation of new set of F₂ and F₃ progenies for shoot fly and stem borer resistance: Fourteen different F₂ and F₃ progenies were evaluated at three locations: NRCS, Hyderabad, Akola, Udaipur for shoot fly and eight progenies tested at two locations viz: Indore, Surat, Warangal for stem borer resistant. The aim of team efforts is to make promising selections as new sources of resistance for genetic diversity against shoot fly and stem bore respectively. Further, a line x tester program involving promising resistant A and R lines and elite lines was undertaken to test the general and specific combining ability, which indicated that probability of obtaining shoot fly resistant hybrids is higher when both the parents are resistant than when either one of the parents is resistant or both the parents are susceptible to shoot fly. These results also

suggested that complementation of shoot fly resistance in both the parent results in resistant hybrids, and there is a need to breed both the parents for resistance to shoot fly in separate program to realize higher frequency of resistant hybrids. Single plant on the basis of less susceptibility and deadhearts free plants were selected. About 88 single plants (seven progenies) from Hyderabad, 71 plants (9 progenies) from Akola and 18 plants (two progenies) from Udaipur were selected for shoot fly (Table 12.1). Similarly, 62 single plants (8 progenies) from Warangal, 34 plants (one progeny) from Indore and 60 plants (from 8 progenies) from Surat were selected (Table 12.2). These will be scrutinized on the basis of seed availability for further testing in 2008.

Trial 12.1: Evaluation of F₃ and new crosses for shoot fly resistance (DNR-SF)-Kharif 2007

Centres: Hyderabad: (Nos: 1-14), Akola: (Nos: 1, 2, 5-7, 9-14), Udaipur (Nos: 13,14)

Sl. No	Shoot fly resistant F ₃ population	Contributing centers	Seed Received (wt in gm)	Seed conditions when received	No of plants selected from centers			
					Hyderabad	Akola	Udaipur	Total
1	PB 12779-2 x SPV 1698	Udaipur	80	good	0	8	NS	8
2	ICSV 272 x CSV 17	Udaipur	90	good	2	11	NS	13
3	IS 18417 x CO 25	Coimbatore	35	40 % ID	0	NS	NS	0
4	IS 18417 x CO 26	Coimbatore	25	70% ID	0	NS	NS	0
5	PSV-56 x SF 94006	Palem	75	20% M	1	7	NS	8
6	PSV-1 x SPV 422	Palem	60	20% M	0	4	NS	4
7	PSV-1 x SPV 462	Palem	65	20% M	0	17	NS	17
8	PSV-57 x SPV 471	Palem	50	70% M	23	NS	NS	23
9	PSV-55 x SFG 94006	Palem	60	35% M	3	4	NS	7
10	M 35-1 x SF 946006	Palem	65	20% M	2	0	NS	2
11	M 35-1 x SF 94001	Palem	35	35% M	0	0	NS	0
12	NTJ 2 x SF 94006	Palem	60	20% M	0	9	NS	9
13	27 B x IS 18551	NRCS	230	good	35	6	9	50
14	IS 2122 x C 43	NRCS	140	good	22	5	9	36

ID = Insect damages seeds, M = Infected with mold, NS = Not supplied

Trial 12.2: Evaluation of F₃ and new crosses for stem borer resistance (DNR-SB) Kharif 2007

Centers: Warangal (Nos: 1-8), Indore (No: 14), Surat (No: 1- 8)

Sl No	Stem borer resistant F ₂ population	Contributing centers	Seed Received (wt in gm)	Seed conditions when received	No of plants selected			
					Warangal	Indore	Surat	Total
1	PSV- 51 x IS 94014	Palem	65	30% M	6	NS	8	14
2	PSV-58 x SPV 471	Palem	65	15% M	9	NS	8	17
3	PSV-58 x SPV 469	Palem	65	15% M	8	NS	8	16
4	M 35-1 x SPSBR-94017	Palem	60	good	13	NS	6	19
5	PSV-56 x 94014	Palem	50	30% M	4	NS	8	12
6	Palem-2 x SPSBR 94017	Palem	70	15% M	5	NS	6	11
7	NTJ-2 x SPSBR 940145	Palem	65	10% M	5	NS	7	12
8	I-12 x ICSV 93046	NRCS	140	good	22	34	7	63

M= Infected with mold, NS=Not supplied

VIII.Validation of IPM modules for shoot pests

Trial 13. Validation of IPM modules for shoots pests in sorghum, Kharif 2007 (Loc: respective locations): New insecticide, Thiamethoxam (Cruiser) tested as seed treatment with or without conventionally recommended insecticides (endosulfan 0.07%, carbofuran and Phorate 10 G at and /or botanical like neem seed kernel extract) with intercropped with either redgram, soybean or moong at three centers (Dharwad, Indore and Udaipur). Whereas, in Parbhani only Thiamethoxam either with endosulfan or NSKE has been tested. The trials were conducted to evaluate cost effectiveness of recommended treatments while managing key pest of sorghum successfully.

Results- Dharwad: Seed treatment of sorghum with Thiamethoxam followed by one spray of endosulfan at 45 DAE reduced the shoot fly damage significantly (17.84 % DH at 28 DAE) and was on par with seed treatment with thiamethoxam in sole sorghum @ 3 kg/ 1 kg of seed at 35 DAE. There was significant difference in sorghum intercropping with and without seed treatment (Table 13.1).

Table 13.1: Validation of IPM modules for shoot pests in Sorghum Kharif 2007, AICSIP, Dharwad
Plot size: 18 rows of 6m, 45cm a part (8.10 X 6m= 48.6 sqm), Replication: 03, Hybrid: CSH 16

Treatments	%DH (Shoot fly)	Stem borer Leaf injury plants (%)	Peduncle damage (%)	Spikelet Damage (%)	Total Sorghum yield q/ha
CSH 16- Untreated	33.70	4.45	13.92	36.67	36.56
Treated CSH 16 with 70WS Thiamethoxam 3g/kg	19.85	8.20	12.73	28.67	41.66
Untreated CSH 16 + Redgram	22.09	9.81	14.33	34.00	46.07
Treated CSH 16 with 70WS Thiamethoxam 3g/kg + Redgram	33.99	7.02	12.61	33.00	37.55
Treated CSH 16 with 70WS Thiamethoxam 3g/kg + followed by spray of NSKE@5 %	29.41	8.21	12.47	31.33	43.98
Treated CSH 16 with 70WS Thiamethoxam 3g/kg + followed + Endosulfan @ 0.07 %	17.83	5.99	13.20	29.33	41.66
Farmers practice	38.93	5.46	12.18	28.67	35.49
Trial mean	27.97	7.02	13.06	31.67	40.42
CD at 5%	11.65	3.31	NS	NS	4.06
CV(%)	33.70	4.45	-	-	18.50

Results-Parbhani: The IPM module showed significantly reduction in the deadhearts caused due to shoot fly especially on sorghum. CSV 15, a commercial variety was used in the trial. Seed treatment of sorghum with Thiamethoxam followed by one spray of endosulfan at 45 DAE reduced the shoot fly damage significantly (22.8% DH at 28 DAE) and was on par with seed treatment with thiamethoxam followed by spray of NSKE 5 % at 45 DAE and sole sorghum seed treated with thiamethoxam and carbofuran @ 7.5 kg/ha at 35 DAE. There was significant difference in sorghum intercropping with and without seed treatment. Seed treatment of sorghum with Thiamethoxam followed by one spray of endosulfan at 30 DAE, seed treatment with thiamethoxam followed by spray of NSKE 5 % at 45 DAE and sole sorghum seed treated with thiamethoxam and carbofuran @ 7.5 kg/ha at 35 DAE were significantly superior in reducing stem borer damage (7.7-7.9%) and were on par with each other (Table13.2).

Sole sorghum seed treated with thiamethoxam and carbofuran @ 7.5 kg/ha at 35 DAE, seed treatment with thiamethoxam followed by spray of NSKE 5 % at 45 DAE and seed treatment of sorghum with Thiamethoxam followed by one spray of endosulfan at 45 DAE were significantly superior in reducing shoot bug damage at 75 DAE (2.4-3.1%) and were on par with each other. Overall the seed treatment of sole sorghum crop with thiamethoxam followed by endosulfan was best and realized yield of 2857.81 kg/ha. However, Intercrop (2.4) without and intercrop with thiamethoxam realized better yield of 4350 and 4015 kg respectively which is attributed to yield due to intercrop (Table 13.2).

Table 13.2: Validation of IPM modules for shoot pests in sorghum, kharif 2007, Parbhani

Treatment	% S.F. D.H at 28 DAE	% Steam borer DH at 50 DAE	% Shoot bug plants At 75 DAE	Sorghum yield in Kg / Plot	Intercrop yield in Kg/plot (Soybean)	Sorghum grain equivalent yield in q/ha.
Sole CSV 15 untreated	35.3	14.1	5.2	4.54	-	20.78
Sole S.T with thiamethoxam + carbofuran @ 7.5 kg/ha at 35 DAE	23.8	7.8	2.4	6.12	-	27.99
Intercrop (2.4) without S.T.	34.4	12.5	4.5	1.52	3.17	43.50
Inter crop with S.T.	26.4	12.3	3.9	1.85	3.35	40.15
S. T. with Thiamethoxam followed by NSKE 5 %	23.7	7.9	3.0	5.54	-	25.97
S.T with thiamethoxam + Endosulfan	22.8	7.7	3.1	6.25	-	28.57
Farmers practice	28.4	11.9	4.5	5.17	-	23.62
Trial mean	27.83	10.60	3.8	4.43	3.26	30.08
CV (%)	3.99	5.16	16.81	4.95		
LSD (0.05)	2.77	0.97	1.14	0.55		

Results-Indore: The IPM trial at Indore comprised of seven treatments. Growing sole sorghum with spray of endosulfan 35 EC @ 0.07% @ 5% at 45 DAE resulted in low shoot fly (3.1% DH at 28 DAE), stem borer (4.05% DH at 45 DAE). This treatment realized high yield of 35.53q/ha (Table 13.3).

Table 13.3: Validation of IPM modules for shoot pests in Sorghum Kharif 2007, AICSIP, Indore

Plot size: 18 rows of 6m, 45cm (8.10 X 6m= 48.6 sqm), Replication: 03, Variety: CSV 15

Treatments	Dead hearts % (SF)	Leaf injury % (Stem borer)	Dead hearts (stem borer)	Grain yield (q/ha)		Sorghum grain equivalent yield (q/ha)
	28 DAE	30 DAE	45 DAE	Sorghum	Soybean	
Commercial cultivars (with out treatment)	11.04 (19.36)	12.09 (28.00)	15.49 (23.15)	17.96		17.96
Seed treatment with Thiamethoxam 70 Ws @ 3g/kg of seed	4.92 (12.83)	19.85 (26.44)	13.46 (21.52)	26.87		26.87
Inter cropping with Soybean 1 : 2 without any treatment	8.91 (17.35)	15.21 (22.61)	7.26 (15.61)	14.25	2.48	20.67
Inter cropping with Soybean (2 : 1) + Seed treatment with Thiamethoxam 70 Ws @ 3g/kg of seed	4.41 (12.10)	12.85 (20.99)	6.66 (14.95)	24.79	1.66	28.00
Sole with treatment > spray of NSKE @ 5% at 45 DAE	3.44 (10.72)	12.91 (21.05)	5.73 (13.85)	25.98		25.98
Sole with treatment > spray of endosulfan 35 EC @ 0.07% @ 5% at 45 DAE	3.10 (10.08)	13.66 (21.64)	4.05 (11.6)	35.53		35.53
Farmers practice (check)	9.52 (17.97)	21.31 (27.47)	8.72 (17.23)	18.92		18.92
Trial	14.35	24.03	16.84	23.47	2.07	24.85
SEm	0.39	0.64	0.43	-		1.38
CD 5%	1.20	1.95	1.29	-		4.19

Result-Udaipur: CSV 17 a commercial variety was treated with Cruiser and intercropped with moong along with the treatments of neem seed kernel extract (NSKE) and endosulfan. Minimum shoot fly damage was observed in seed treatment with thiamethoxam 70 WS at 3 g/kg seed along with one spray of NSKE (5%) at 45 DAE and found significantly better over rest of the treatments. Regarding stem borer infestation minimum was recorded in seed treatment with thiamethoxam 70 WS at 3 g/kg seed with one spray of endosulfan 35 EC (0.07%) which was at par with seed treatment +one spray of NSKE (5%) as well as seed treatment + intercropped with moong. On the basis of grain yield maximum was achieved in seed treatment with thiamethoxam 70 WS at 3 g/kg seed with spray of NSKE (5%) at 45 DAE followed by same seed treatment with spray of endosulfan 35 EC (0.07%) at 45 DAE. Over all seed treatment with thiamethoxam 70 WS at 3 g/kg seed proved better in terms of lowest shoot fly and stem borer damage with higher grain yield. Although sorghum based moong inter-cropping is profitable in terms monetary gain (Table13. 4).

Table 13.4: Validation of IPM modules for shoot pests in sorghum, kharif 2007, Udaipur

Commercial cultivar used = CSV 17, Plot size = 16.20 sq. m.

Treatment (s)	Dead heart %		Sorghum equivalent grain yield (kg/plot*)	C :B Ratio
	Shoot fly	Stem borer		
Commercial cultivar (without treatment)	50.05 (58.76)*	22.81 (15.02)*	4.17	1 : 1.61
Seed treatment with Thiamethoxam 70 WS (@ 3 g/kg of seed)	40.44 (42.07)	19.92 (11.60)	5.47	1 : 1.92
Intercropping with moong (2:1) with out any treatment	48.17 (55.46)	24.12 (16.69)	4.73	1 : 2.76
Intercropping with moong (2:1) with out any treatment + seed treatment with Thiamethoxam 70 WS (@ 3 g/kg of seed)	40.21 (41.67)	19.43 (11.06)	5.58	1 : 2.92
Seed treatment with Thiamethoxam 70 WS > spray of NSKE @ 5 % at 45 DAE	37.04 (36.28)	18.61 (10.18)	6.00	1 : 2.07
Seed treatment with Thiamethoxam 70 WS > spray of endosulfan 0.07 % at 45 DAE	40.02 (41.35)	18.01 (9.55)	5.93	1 : 2.00
Farmers practice (check)	52.93 (63.66)	24.95 (17.79)	2.48	-
Mean	48.46	13.12	4.91	
CD (p =0.05)	1.714	1.704	0.869	-

* Figures in parenthesis are retransformed per cent values