Methodology on sorghum pest surveillance and screening trials and nurseries for insect pest resistance

Pest surveillance, seasonal abundance, and population dynamics of sporadic and unusual pest outbreaks

In view of changing scenario of different insect pests at different locations, surveillance of key, minor, and sporadic pests, and natural enemies should be undertaken at periodical intervals. Quantification of extent of crop losses in the farmers' field at two fixed sites will be continued.

- Totally, 4-8 trips at fortnightly intervals (from the time of germination till harvest) are required to undertake surveys by both Entomologists and Pathologists.
- The Officer-Incharge of the stations will be responsible for providing the transport facility for the purpose; otherwise they can claim the TA and DA.
- Two sites (a village or a large growing area) beyond 8 km from the research station in two opposite directions (particularly in core sorghum growing areas) should to be selected and monitored.
- Similarly, cultivars occupying more area as well as 1 km away from the FLDs plot should to be selected.
- For large-scale survey work, two trips (one at the early vegetative stage, and another at the milk stage need to be made. The report for the survey carried out at the vegetative stage must be sent much before flowering time, and the final report within 10 days after the trial harvest.
- The report must be sent to PI (Entomology), NRCS, Hyderabad. In view of increasing importance and changing status of minor, sporadic, and unusual pest epidemics such as Pyrilla perpusilla, Myllocerus sp., flea beetle, sugarcane aphid, phadka grasshopper, and shoot bug,. Studies on the ecobiology, seasonal abundance, and factors contributing to pest outbreaks need to be initiated.
- In addition, data on biological control agents must be recorded. A proforma has been developed to collect data on pest abundance, and made available to all Entomologists in AICSIP (Please see annexure V).

National Sorghum Insect Pest Resistance Screening Trials and Nurseries

Introduction: The prime objective of the sorghum improvement program is to increase and stabilize crop production in the sorghum growing areas at National level. To achieve this goal, it is necessary to provide the national programs with genotypes, which have higher and stable yield potential than those currently grown by the farmers. One of the important objectives of AICSIP research program is to identify sources of resistance for various insect pests from the world germplasm, and use them in the pest resistance-breeding program. To ensure that such resistance is broad based, it is necessary to test the material under various levels of insect infestation and under different environmental conditions.

The Sorghum Insect-Pest Resistance Testing Program is a team effort under AICSIP aimed at:

- to identify stable and effective resistance sources to insect pests
- to distribute the insect resistant sorghum lines to interested scientists
- to provide information on variability in insect populations at different locations
- to act as a multidisciplinary and communication link mainly between entomologists and breeders and others like phytochemist, physiologist, agronomist in different regions.

When and how to sow

- The planting time should be adjusted such that the susceptible stage of the crop is exposed to maximum and uniform density of the target pest (example: for stem borer –should be sown at normal time, for shoot fly-3 to 4 weeks later than normal sowing).
- The crop should be thinned one week after seedling emergence; with a plant to plant distance of 10-12 cm.
- Recommended package of agronomic practices should be followed for raising the crop.
- No insecticide should be applied in this experiment, but plant protection measures may be adopted to control non-target insects depending upon the objectives of the experiment.
- The trial should be sown to generate the pest data (pest specific trials).

Methodology for observations

Sorghum shoot fly (Atherigona soccata)

- Record the total number of plants per plot, and the plants with eggs, and the total number of eggs at 14 or 21 days after seedling emergence (DAE).

- Count the number of plants with deadheart symptoms at 21 or 28 DAE. Distinguish the plants with shoot fly and stem borer deadhearts.
- Plants with stem borer deadhearts have leaf feeding symptoms, and more than one leaf becomes dry, while in case of shoot fly, normally one leaf dries up.
- Additional data may be recorded at maturity on number of tillers and the tillers with productive panicles.
- Also record data on days to 50% flowering, plant height, and grain yield per plot at maturity.

Stem borer (Chilo partellus)

- To screen for resistance to spotted stem borer, the material should be tested at the hot spot locations, or infested artificially with neonate larvae (3 to 5 larvae per plant) at 18 to 20 DAE.
- Record the data on total plants, leaf feeding symptoms at 30 DAE (1 = <10, 2 = 11 – 20, 3 = 21- 30, 4 = 31 – 40, 5 = 41 – 50, 6 = 51 – 60, 7 = 61 – 70, 8 = 71 – 80, and 9 = >80% leaf area damaged by the larvae), and plants with deadhearts at 45 DAE (25 days after artificial infestation).
- At maturity, additional data may be recorded on number of tillers, tillers with productive panicles, number of exit holes per 5 plants, stem tunneling (5 plants per plot), number of harvestable panicles, and the number of chaffy and broken panicles.

Sugarcane aphid (Melanaphis sacchari)

- The nymphs and adults suck sap from the undersurface of leaves. The damage starts from lower to upper leaves. Heavy infestation results in stunted plant growth, drying up of leaves, and plant mortality.
- The damage is more severe in crops under drought stress. The aphids secrete honeydew, which falls on the leaves and on the ground, on which sooty molds grow. Sorghum planted in late November is heavily infested with M. sacchari.
- Aphid damage can be evaluated in a 1 - 9 scale (1 = a few aphids present with no apparent damage to leaves, 2 = lower 1 – 2 leaves with aphid infestation without severe damage to the leaves, 3 = 2 – 3 leaves with aphid damage, 4 = 3 – 4 leaves with aphid damage, 5 = 3 - 4 leaves with severe aphid damage, 6 = 4 to 5 leaves with severe damage symptoms and covered with aphids on the undersurface, 7 = 5 to 6 leaves with severe aphid damage and covered with aphids on the undersurface, 8 = 7 – 8 leaves with severe aphid damage, and 9 = most of the leaves damaged by the aphids, and plant showing symptoms of stunting and drying).
- Record grain yield at maturity. At peak infestation (normally around milk stage), additional data can be recorded on the number of aphids per unit area on three leaves in the middle in five plants selected at random.
- The test material can also be maintained under infested and un-infested conditions for comparison or protected and non-protected conditions.

Shoot bug (Peregrinus maidis)

- The corn plant hopper or shoot bug is cosmopolitan pest and its outbreaks have become frequent during dry spells in the rainy and the post-rainy seasons.
- Adults and nymphs usually congregate in leaf whorls, inside leaf sheaths, and panicles. Adults and nymphs suck the plant sap, resulting in stunting and yellowing of leaves. Severe infestations result in gradual withering of leaves or twisting of top leaves and inhibition of panicle formation.
- To record insect numbers or extent of oviposition, select five plants in each replication at random at 45 and 60 days after seedling emergence. Enclose the samples in a polythene bag, place a cotton swab soaked in chloroform to immobilize the insects, and count the number of insects on each plant. Remove the leaves from each plant carefully, split the midribs, and examine for eggs under a binocular microscope.
- Plant damage symptoms can also be recorded at 60 - 75 days after seedling emergence on a 1 to 9 scale (1 = a few shoot bugs present on the plant, and no apparent damage to the leaves, 2 = shoot bugs present in the leaf whorls and leaf sheaths with a few feeding specks, 3 = 10% leaf/leaf sheath area showing feeding symptoms, 4 = 20 to 30% leaf/leaf sheath area showing feeding/oviposition damage, 5 = 30 to 40% leaf/leaf sheath area showing feeding/oviposition damage, 6 = 40 –50% damage to leaves/leaf sheaths, and 4 to 5 leaves showing symptoms of twisting and oozing of cell sap, 7 = 5 – 6 leaves showing extensive feeding, twisting, and oozing of cell sap, 8 = 7 – 8 leaves showing extensive feeding, twisting, and oozing of cell sap, and 9 = plants heavily infested with shoot bugs and most of the leaves twisted, and no panicle exertion).

Sorghum midge (Stenodiplosis sorghicola)

- Sorghum midge larvae feed on developing grain resulting in production of chaffy spikelets. Hot-spots, sowing date, split sowings, infester row technique, selective use of insecticides to control other insects, and grouping the material according to maturity and height increase the efficiency of screening for resistance to sorghum midge.
- Caging sorghum midge females with sorghum panicles at flowering permits screening for resistance under uniform insect pressure.

- Releasing 40 midges into each cage for 2 consecutive days is very effective to screen for resistance to sorghum midge.
- Remove the cages 15 days after infestation and evaluate the midge damage.
- Record sorghum midge damage in 250 spikelets at 15 days after flowering or at maturity. Collect five primary branches each from top, middle, and bottom portions of each panicle. Bulk the spikelets from all the panicles, split into secondary branches. Record the number of chaffy spikelets in a sample of 250 spikelets.
- At the milk stage, squeeze the chaffy spikelets with forceps, and record the numbers of spikelets producing red ooze.
- Evaluate midge damage on a 1 to 9 scale (1 = <10, 2 = 11 – 20, 3 = 21 – 30, 4 = 31 – 40, 5 = 41 – 50, 6 = 51 - 60, 7 = 61 – 70, 8 = 71 – 80, and 9 = >81% midge damaged spikelets). Record grain yield at maturity.

Head bug (Calocoris angustatus)

- Ear head bugs, Calocoris and Eurystylus are serious pests of sorghum in Asia and Africa. The nymphs and adults suck the sap from the developing grain, which results in tanning and shriveling of the grain. Adjust sowing dates such that flowering of the test material coincides with maximum head bug density.
- Group the test material according to maturity and height, and include resistant and susceptible checks of appropriate maturity. Sow the test material in two sets at an interval of 10 - 15 days to reduce the chances of escape. Plant four rows after every 16 - 20 rows of the test material.
- Collect head bugs from other fields and spread in the infester rows at panicle emergence. For no-choice head-cage screening, infest each panicle with 10 head bug pairs at the 50% flowering stage.
- Data can be recorded on head bug numbers at 20 days after flowering or infestation.
- At maturity, evaluate head bug damage visually on a 1- 9 scale (1 = grains fully developed, and a few grains with feeding punctures, 2 = grain fully developed and with feeding punctures, 3 = grains showing slight tanning or browning, 4 = most grains with feeding punctures and a few showing slight shriveling, 5 = grains showing 25% shriveling and browning, 6 = grains showing more than 50% shriveling and tanned, 7 = most of the grain highly shriveled and highly tanned, 8 = grain highly shriveled and slightly visible outside the glumes, and 9 = Most of the grains highly shriveled and almost invisible outside the glumes).
- Harvest all panicles from the middle row(s) of each plot or genotype at maturity and record grain yield in each plot or panicle.

Development of new sources of insect resistance / pre-breeding material for genetic diversity (group effort)

- Must be in collaboration Breeders in collaboration with entomologists are required to generate crosses with increased genetic diversity by extensively using the resistance donors for different insect pests and share the material right from the F2 onwards.
- Minimum 500 plant populations for F2/F3. (Spacing 45 x 10-12 cm) and generation will be advanced till F6 and then stabilized material will be supplied to hot spot locations for further evolution. Single plant selection by entomologist and breeder should be done.
- Report to be submitted along with details of resistant sources used, complete pedigree, etc. The elite resistant sources emerging from this program in desirable agronomic background should form the basis of resistant nurseries maintained by the respective centers before passing on for multi-location testing.
- However, highly significant levels of resistance in diversified genetic backgrounds, not necessary with high grain yield, should also be provided to test the hypothesis.

NOTE: Some germplasm lines and breeder's material have been identified as resistant to shoot fly and stem borer under AICSIP. It is proposed to test this material under different environmental conditions to identify diverse and stable sources of resistance to these pests. The guidelines for conducting the trial and data sheets are included with the seed material. Enough seed has been provided for three replications (2 rows of 4 meter length). When the experiment is completed, one copy of data sheet should be sent back to us for our information and compilation of the results

Validation of IPM modules for shoot pests

Validation of location specific IPM modules for shoot pests has to be conducted at AICSIP centres based on the local recommendations with improved varieties. The following trial is proposed. It can be differed depend upon the requirement of the region.

Planting	:	normal
Plot size	:	18 rows of 9 m (8.1 x 9 m) = 72.9 sqm, Spacing 45 x 15 cm,
Replications	:	03

Treatments

1) Sole commercial cultivar (without any treatment)
2) Sole crop with seed treatment (Thiomethoxam 70 WS (@ 3 g/kg of seed)
3) Intercropping with legumes without any treatment (as per agronomic cropping system recommendations)
4) Intercropping with legumes (as per agronomic cropping system recommendations) + seed treatment with Thiomethoxam 70 WS (@ 3 g/kg of seed)
5) Sole crop with seed treatment (Thiomethoxam 70 WS @ 3 g/kg of seed) > spray of NSKE spray @ 5% at 45 DAE
6) Sole crop with seed treatment (Thiomethoxam 70 WS @ 3 g/kg of seed) > spray of endosulfan 0.07% at 45 DAE
7) Farmers practice (check).

For more details, refer to information bulletins on "Techniques to screen sorghums for resistance to insects" and "Mechanisms of resistance to insects in sorghum" "Sorghum descriptors" published by ICRISAT.

Important suggestions and responsibility

I. Pest Survey

1) In view of changing scenario of different insect pests at different locations, a critical survey of surveillance of key, minor, and sporadic pests and natural enemies will be continued. A survey proforma will be sent to all centers. Please provide pest information in the format only. The pest survey will be undertaken by both Entomologists and Pathologists.
2) It was felt that minimum four trips would be possible to undertake pest surveys (from the time of germination till harvest) due to transport constraints in SAUs.
3) The cultivars occupying more area as well as 1 km away from the FLDs plot are to be selected. For large-scale survey work, two trips (one at early vegetative stage and another at milk stage need to be made.
4) The survey report carried out at the vegetative stage must be sent much before flowering time and also the final report within 10 days after the trial harvest. The report must be sent to PI (Entomology), NRCS, Hyderabad.

II. Technical

1) The data collected over the years earlier by the Entomologist(s) at respective centers, should be consolidated in the form of a progress report or monographs.
2) The level of shoot fly infestation in susceptible check should be > 70% dead hearts (both in kharif and Rabi season) for screening Varietal/hybrid trials. The data shows > 30 % CV should not be considered for comparison.
3) The data on shoot fly dead hearts will be required to record at peak period of infestation and glossiness rating (1 to 9) to be recorded at 14 DAE as the base for shoot fly dead hearts observations.
4) It is once again reiterated that all the Entomologists should uniformly include the resistant, susceptible, and local checks, so that the level of infestation can be known to draw valid conclusions. Also, requested to use the common parameters for each pests at all locations as discussed in the agm06 (one can have additional check other than mandatory national check).
5) Ensure high and uniform pressure of infestation in all the screening trials, especially for shoot fly, using fish-meal and infestor rows and please adhere to the uniformity while reporting data on all the insect resistant parameters as discussed.
6) Experiment with fish-meal in infestor rows alone: The experiment is to be conducted by applying fish-meal to infestor rows alone, but not to test entries. Techniques of applying fish-meal (take 50 g of fish meal or 50 g of dry fish in polythene bag and moisten it slightly and keep it between the plants in a row. Keep such two bags (@ one bag/row).

III. Receipt of Seeds and data

1) Please send the seed of PR lines (300 g each) before 23rd May, 2007 for Kharif and before 15th August, 2007 for Rabi to NRCS for further distributions.
2) Very little information on cost-benefit ratio along with additional net returns has been furnished for all the trials on chemicals, biological, and IPM practices. Therefore, furnish all necessary information. Please mention net plot size (sq m) harvested for calculating grain yield kg/ha.
3) Three years data on IPM recommendations may be compiled and published. Similarly, three years data on effectiveness of new chemical will also be required to publish.
4) All the Entomologists are requested to send the data booklets of one copy to the PI (Entomology), AICSIP, NRCS, Hyderabad, by furnishing the replicated data. Please strictly adhere to the sequence of entries furnished in the list along with the trial seed supplied. The data should be sent in two batches: 1) early part of the growth, 2) at harvest. Please adhere to the submission of all data booklets filled latest by Nov 30, 2008 for Kharif and Feb 15 for Rabi season trials. In addition, detailed analyzed report of each centre should be submitted by Dec 15, and March 1, respectively for kharif and Rabi season trials, respectively. The data should be clearly written (not with a pencil) or typed clearly and legibly. It would be

encouraged to send the data in MS Excel file in a CD as well as a hard copy of complete original data. You must retain all original notebooks.

5) Maintain the seed material of resistant sources identified/developed at their respective centers with their known pedigrees.
6) The details on pedigree, crosses, etc., must be supplied to the testing centers, so that trials will be considered for screening under AVT, IVT, AHT, IHT, SPN and PLT.
7) Two rows of 4 m length with 2/3 replications are to be sown in evaluation trials for two times, whereas the minimum plot size in IPM trials, 20 sq m in Kharif and Rabi should be maintained.

IV. Publications

A list of publications (research journal, bulletins, posters, conference paper, pamphlets, leaf lets etc) with standard bibliography should be provided every year by all entomologists. Please send one set of reprints or prints to PI for compilations. This will be uploaded on NRCS website for information and reference to other scientist.

V. Administration

1) The Officer-Incharge of the Stations will be responsible for providing the transport facility for the purpose; otherwise they can claim the TA and DA. Two sites (a village or a large growing area) beyond 8 km from the research station in two opposite directions (particularly in core sorghum growing areas) are to be selected and monitored.
2) A training program will be organized during August at NRCS & ICRISAT. This will enable all young entomologists/pathologists for gaining knowledge and will be ensure consistency in recording different parameters of resistance to key, minor, and sporadic pests.
3) Please see that an entomologist should work at least three consecutive years at one locations. This will not disturb the process of testing program.

Please send the results to:

Dr V.R Bhagwat, Principal Investigator (Entomology)
NRC for Sorghum, Rajendranagar, 500 003, A.P., India
Ph: 040 -24015349 extn 210; Fax: 040- 24016378 E-mail: bhagwat@nrcsorghum.res.in

Annexure-I: Parameter for Insect Resistance (to be considered during data recording)

Pest	Crop age (days)	Resistance parameters
Shoot fly	14 & 21	No. of seedlings with eggs, No. of eggs / 10 seedlings
	14, 21 & 28 Maturity	Deadhearts (%) No. of tillers
	Maturity	No. of productive tillers
	14 & 21	Seedling vigor (1-9)
	14 & 21	Leaf glossiness (1-9)
	14 & 21	Seedling height (cm)
	14 & 21	Seedling weight / 5 seedlings
	28	No. of nodes / 5 plants
	60	Plant pigment (Purple or tan)
	60	Leaf midrib colour (green, white, yellow, brown or purple)
	70 Maturity	Waxy bloom (1-9) Panicle compactness (compact, semi-compact or loose)
	Maturity	Panicle length
	Maturity	Glume colour
	Maturity	Glume covering
	Maturity	Presence of awns
	Maturity	Grain pericarp colour
	After threshing	100 seed mass (g)
	Flowering	Days to 50 % flowering
	Milk stage	Plant height (cm)
	After threshing	Grain yield/5 plants (g)
Stem borer	30 & 45	Leaf feeding score (1-9)
	30 & 45	Leaf injured plants (%)
	30 & 45	Deadheart (%)
	At harvest	No. of exit holes / 5 plants
	At harvest	Stem tunneling (%)
	At harvest	No. of tillers
	At harvest	No. of harvestable panicles
	Before harvest	No. of chaffy grains/broken panicles
	60	Plant pigment (purple or tan)
	60	Leaf midrib colour (green, white, yellow, brown or purple)
	70	Waxy bloom (1-5)
	Maturity	Panicle compactness (compact, semi-compact or loose)
	Maturity	Panicle length
	Maturity	Glume colour
	Maturity	Glume covering
	Maturity	Presence of awns
	Maturity	Grain pericarp colour
	Maturity	After threshing 100 seed mass (g)
	Flowering	Days to 50 % flowering
	Milk stage	Plant height (cm)
	After threshing Anthesis	Grain yield/5 plants (g) Days to 50 % anthesis (days after planting), Duration of anthesis
Midge	Anthesis	Adult midges attracted/5 panicles(no.)
	At harvest	Spikelet damage (%)
	Before harvest	Panicle damage rating (1-9)
		After threshing Grain yield/5 plants (g)
Head bug	Anthesis	Days to 50 % anthesis (days after planting) Duration of anthesis
	Anthesis & milky stage	Adult bugs colonized / 5 panicles
	Anthesis & milky stage	Nymphs colonized / 5 panicles
	Before harvest After threshing	Panicle damage rating (1-9) Grain yield/5 plants (g)
Headworms	Flowering	Eggs (no.)/5 panicles
	Flowering, milk, soft & dough stage	No. of larvae / 5 panicles
	After threshing	No. and weight of healthy & damaged grains/5 panicles
Sugarcane aphid	30,45 & 60	Population abundance rating (1-9)

Pest	Crop age (days)	Resistance parameters
	30,45 & 60	Plant damage rating (based on necrosis) (1-9)
	30,45 & 60	Leaf erectness
	30,45 & 60	Leaf waxiness
	30,45 & 60	Resistance rating (1-9)
Shoot bug	30,45 & 60	Brachypter & Macropter adult colonization / 5 plants(no.)
	30,45 & 60	Nymphal colonization / 5 plants (no.)
	60	Plant pigments (purple & tan)
	60	Leaf erectness
	30,45 & 60 30,45 & 60	Leaf waxiness Plant damage (%)
Armyworm	30,45 & 60	Foliar damage rating (1-9)
	30,45 & 60	Larval population/whorl in 5 plants (no.)
	30,45 & 60	Larval population / panicle in 5 plants (no.)
Spider mite	Hard dough	Foliar damage rating
	Flowering & soft dough	Leaf waxiness
	Before harvest	Plant mortality

Annexure-II: 'Hot spot' or endemic locations for major insect pests in sorghum

Insect pest	Location/Centre			
	Kharif season	Total centres	Rabi season	Total centres
Shoot fly	Coimbatore, Palem, Dharwad, Parbhani, Akola, Indore, Surat, Udaipur	8	Bijapur, Parbhani, Rahuri Dharwad	4
Stem borer	Delhi, Warangal, Surat, Indore, Hisar	5	Kovilpatti, Rahuri, Parbhani	4
Midge	Dharwad	1	Kovilpatti	1
Head bug	Coimbatore, Palem, Indore	3	Kovilpatti	1
Sugarcane aphid	Indore	1	Bijapur, Parbhani, Rahuri, Solapur	4
Shoot bug	-		Bijapur, Solapur, Parbhani	3

Annexure-III: Resistant, susceptible, and local/qualified checks for grain sorghum trials

Insect pest	Entries/Checks		
	Resistant	Susceptible	Local/Qualified
Kharif season			
Shoot fly	IS 2312, IS 18551, & ICSV 705	DJ 6514	CSV 17, SPV 1616, SPV 462, CSH 18 (or add recent checks)
Stem borer	IS 2205 & ICSV 714	DJ 6514	CSV 17, SPV 1616, SPV 462, CSH 18 (or add recent checks)
Midge	DSV 3 (ICSV 745) & DJ 6514	IS 2312	CSV 17 SPV 462, CSH 18(or add recent checks)
Head bug ***Rabi season***	IS 17610, IS 17645, & IS 21444		CSV 17, SPV 462, SPV 1616, CSH 18(or add recent checks)
Shoot fly	RSE 3, IS 2312, & IS 18551	DJ 6514	M 35-1, CSV 216R & Maulee (or add recent checks)
Stem borer	IS 2205	CSV 1 (Swarna), DJ 6514	M 35-1, CSV 216R & Maulee(or add recent checks)
Shoot bug	Y 75	Hathi kunta	M 35-1, CSV 216R & Maulee(or add recent checks)
Sugarcane aphid	T x 428, C 43	296B	M 35-1, CSV 216R & Maulee (or add recent checks)

Note: The maintenance of resistant sources developed or identified by the respective centers should be the responsibility of the location entomologist. The entomologists will be a partner while registering the resistant sources with the NBPGR (identified/generated from respective centers).

Annexure-IV: Scoring (scale: 1-9) for Biotic Stress 1= Most desirable, 9=Least desirable

Pest	1	2	3	4	5	6	7	8	9	Remarks
Stem borer (*Chilo partellus)*	<10 %	11 – 20 %	21- 30 %	31 – 40 %	41 – 50 %	51 – 60 %	61 – 70 %	71 – 80 %	> 80%	Leaf feeding at 30 DAE
Sugarcane aphid (*Melanaphis sacchari)*	A few aphids present with no apparent damage to leaves	Lower 1 – 2 leaves with infestation without severe damage to the leaves	2 –3 leaves with aphid damage	3 –4 leaves with aphid damage	3 -4 leaves with severe aphid damage	4 to 5 leaves with severe damage symptoms and covered with aphids on the undersurface	5 to 6 leaves with severe aphid damage and covered with aphids on the undersurface	7 –8 leaves with severe aphid damage	Most leaves damage, symptoms of stunting and drying	Aphid damage
Shoot bug (*Peregrinus maidis)*	A few shoot bugs present on the plant, and no apparent damage to the leaves	Shoot bugs present in the leaf whorls and leaf sheaths with a few feeding specks	10% leaf/leaf sheath area showing feeding symptoms	20 to 30% leaf/leaf sheath area showing feeding/oviposition damage	30 to 40% leaf/leaf sheath area showing feeding/oviposition damage	40 –50% damage to leaves/leaf sheaths, and 4 to 5 leaves showing symptoms of twisting and oozing cell sap	5 –6 leaves showing extensive feeding, twisting, and oozing of cell sap	7 –8 leaves showing extensive feeding, twisting and oozing of cell sap	Plants heavily infested with shoot bugs and most of the leaves twisted, and no panicle exertion	Plant damage at 60-75 DAE
Sorghum midge (*Stenodiplosis sorghicola)*	<10 %	11 – 20 %	21 – 30 %	31 – 40 %	41 – 50 %	51 – 60 %	61 – 70 %	71 – 80 %	>81 %	Spikelet damaged at milky stage
Head bug (*Calocoris angustatus)*	Grains fully developed, and a few grains with feeding punctures	Grain fully developed and with feeding punctures	Grains showing slight tanning or browning	Most grains with feeding punctures and a few showing slight shriveling	Grains showing 25% shriveling and browning	Grains showing more than 50% shriveling and tanned	Most of the grain highly shriveled and highly tanned	Grain highly shriveled and slightly visible outside the glumes	Most of the grains highly shriveled and almost invisible outside the glumes	Head bug damage at Maturity

Annexure-V: Format for recording pest survey data from farmer's field-year

Sample/ Field No. (Visit)	Meteorological std week No.	Location	District	Name of cultivar/Hybrid	Date of survey	Date of sowing	Age of crop & crop stage	Season	Cropping pattern (Sole, inter, relay etc)	Shoot fly (DH%)	Stem borer (%DH)	Midge Spikelet damage (%)	Head bug panicle damage rating (1-9)	Shoot bug damage (%)	Pyrilla damage rating (1-9)	Other pests if any	Soil type, previous crop, irrigated, Rainfed	Plant protection measures taken	Remark
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20